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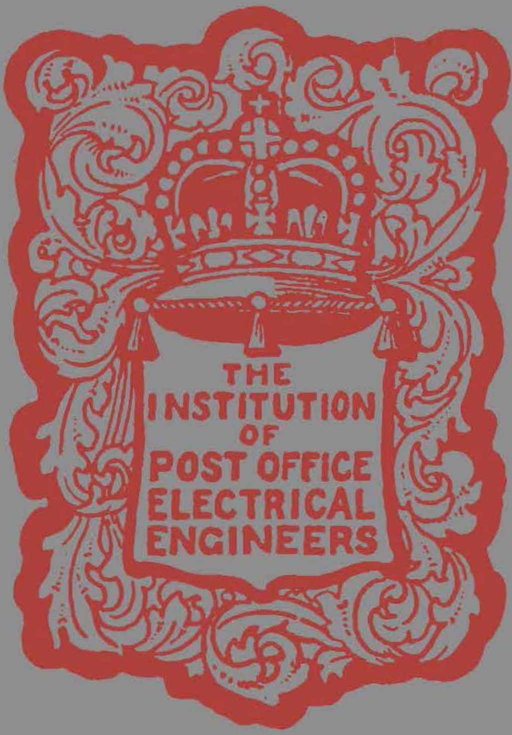

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	PAGE
THE THEORY OF THE SHUNTED CONDENSER—A. B. Morice	1
ALARMS, REPEATER, No. 3	18
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM ...	24
MECHANICAL AIDS: SOME ASPECTS OF "AUTOMATIC" TELEPHONE WORK—W. Wheeler	25
LETTERING OF RELAYS IN AUTOMATIC TELEPHONE DIAGRAMS ...	43
TESTING-OUT AUTOMATIC EXCHANGES—W. Prickett	45
SUBMARINE CABLE WORK IN TIDAL WATERS—J. S. Brown	48
RUGBY RADIO STATION—T. Walmsley	59
THE TESTING OF INSULATING MATERIALS FOR USE AT HIGH FREQUENCIES	65
NOTES AND COMMENTS	69
HEADQUARTERS NOTES	77
MR. E. H. SHAUGHNESSY	79
OLIVER HEAVISIDE, F.R.S.	82
THE VOCATION OF THE ELECTRICAL ENGINEER—Thomas Boyes Johnson	90
LONDON DISTRICT NOTES	94
MR. E. H. FARRAND	96
MR. C. H. CHAPMAN	98
I.P.O.E.E. LOCAL CENTRE NOTES	99
BOOK REVIEWS	107
BOOKS RECEIVED	109
STAFF CHANGES	110
COMMUNICATIONS	114

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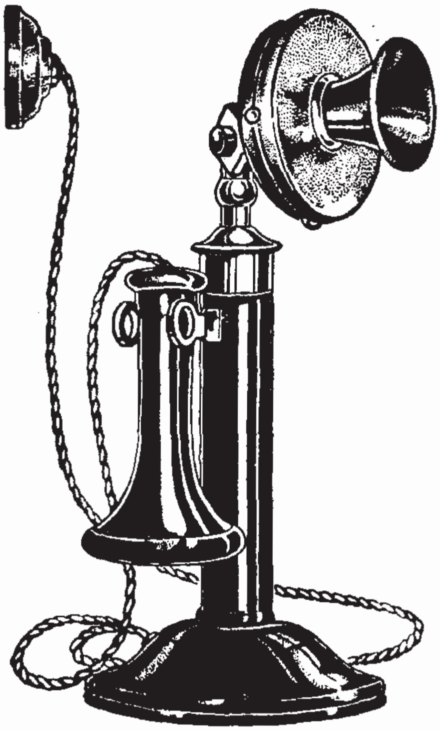

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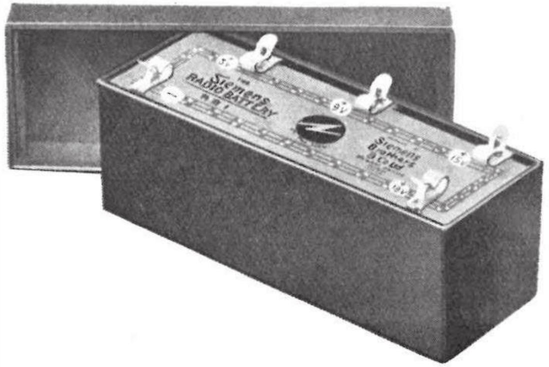

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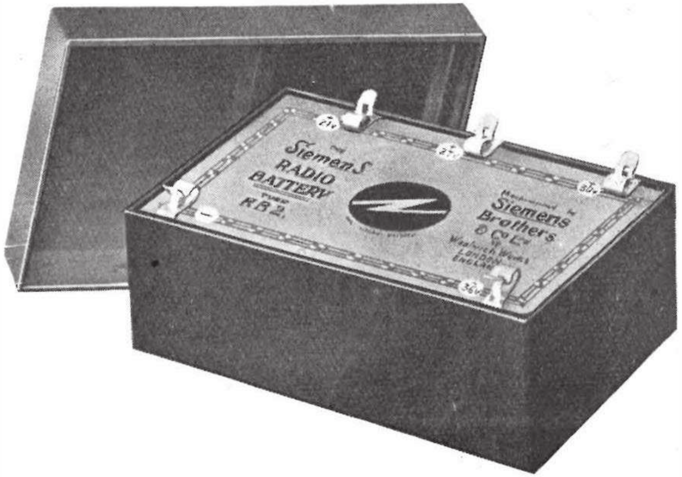

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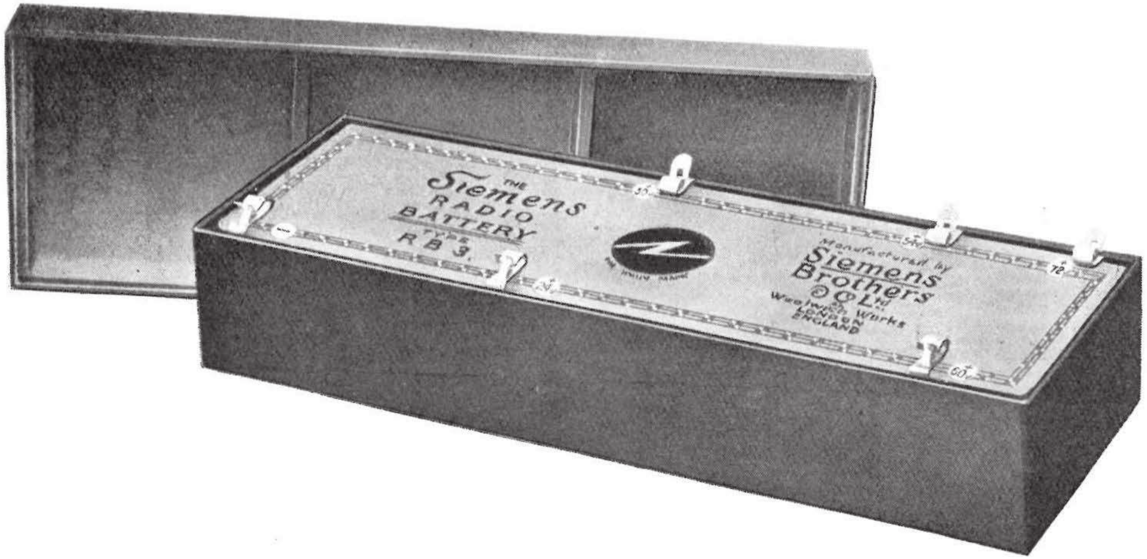
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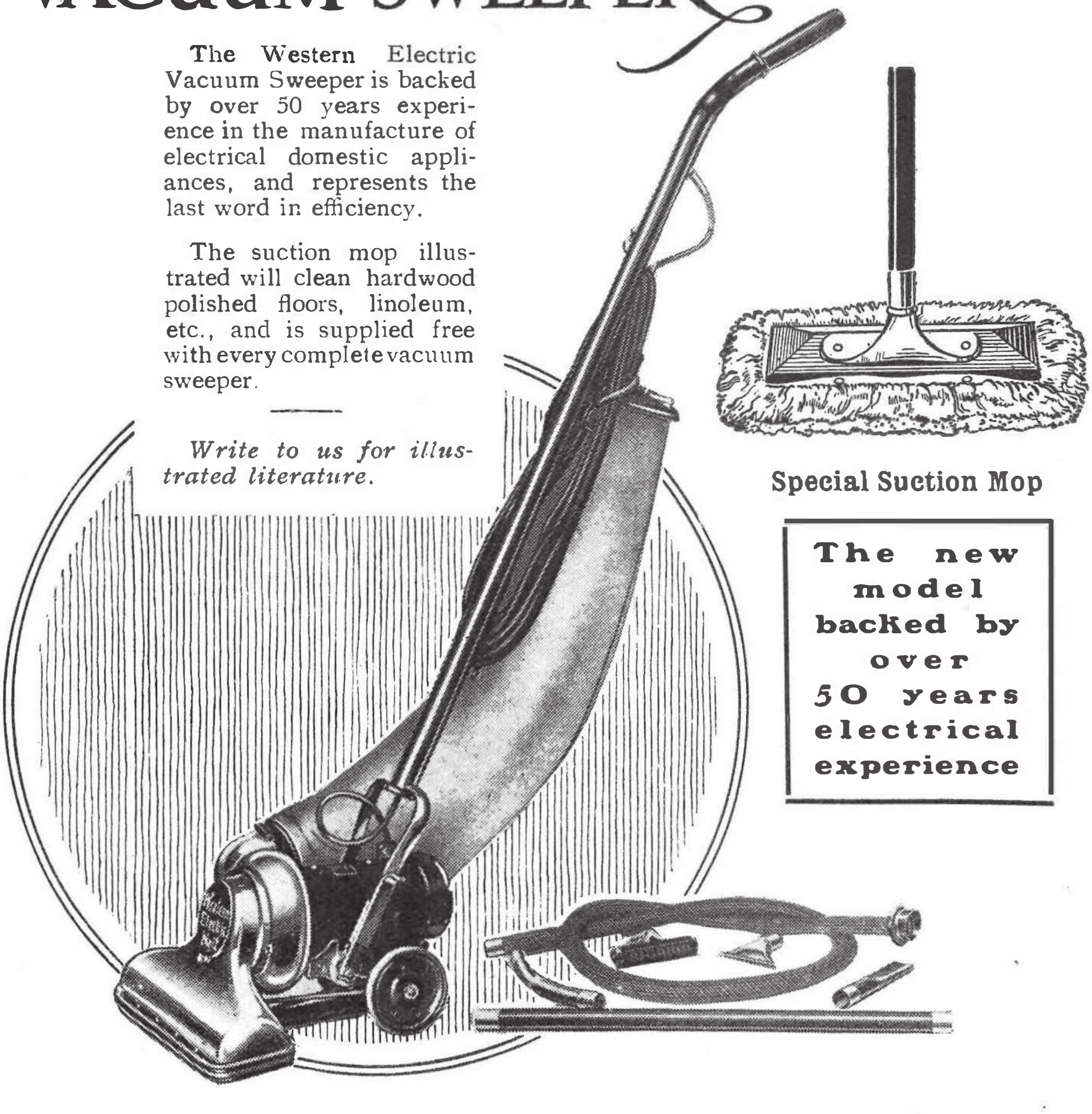

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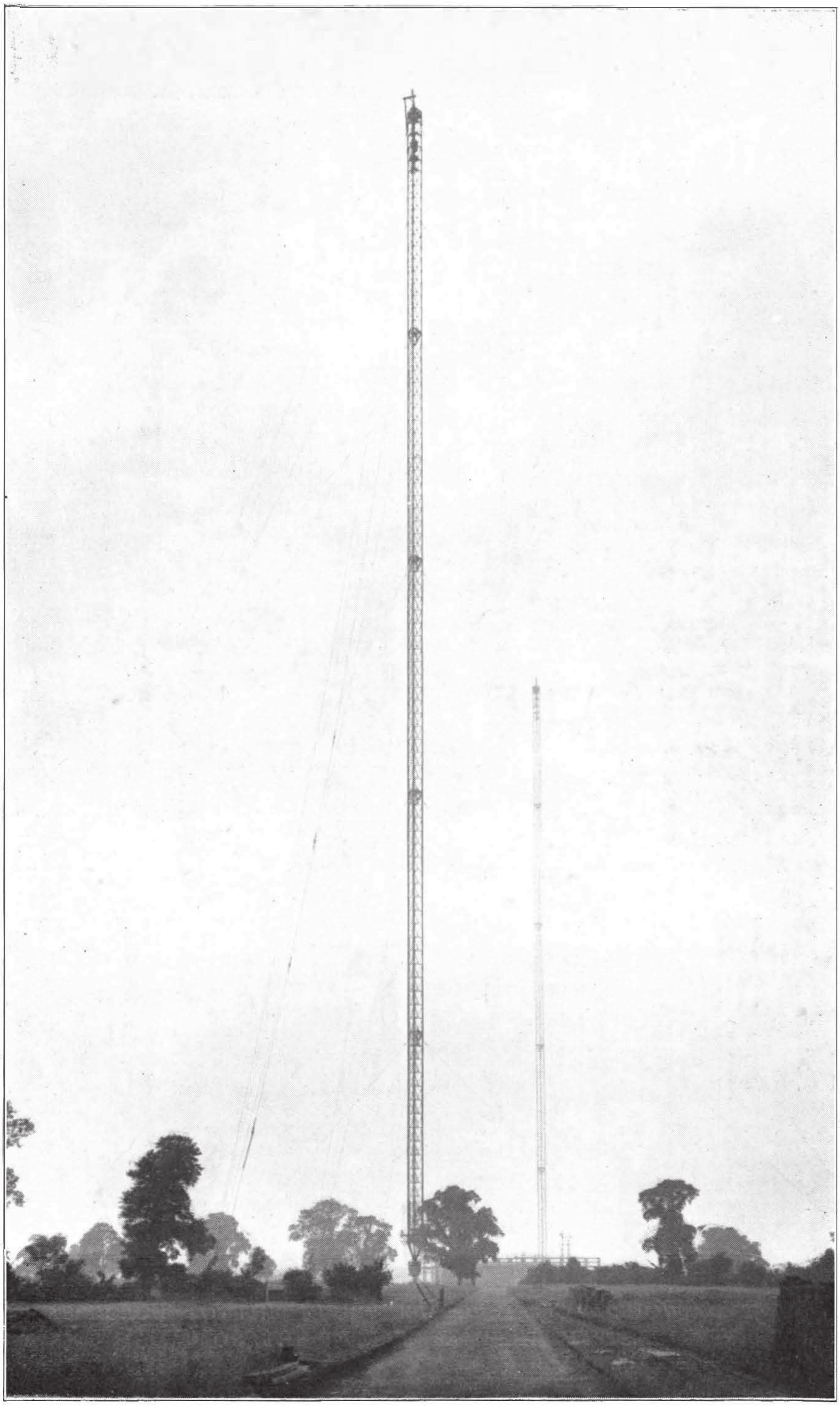

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THE
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THE THEORY OF THE SHUNTED CONDENSER.

By A. B. Morice, B.Sc. (Eng.), A.M.I.E.E.

The well-known circuit shown in Fig. I is usually employed for the reception of telegraph signals above a certain speed, the shunted condenser being used to increase the rate of rise of the signal current in the relay or receiver coils.

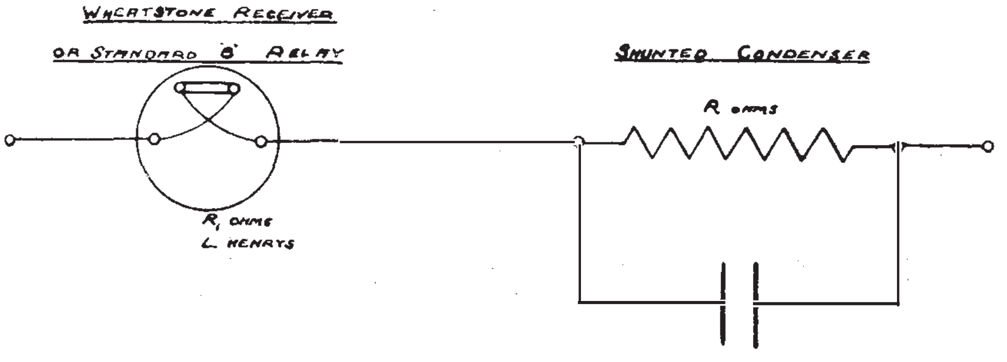


FIG. I

The writer recently carried out an investigation of the effect of a shunted condenser on the rate of rise of the current in the coils of a Standard "B" Relay. It is proposed in this article to give a brief outline of the results obtained which, it is thought, will prove interesting and instructive. These results lead to conclusions which should apply equally to a Wheatstone Receiver or a Standard "B" Relay as the coils and magnetic circuit of the two instruments are of the same design.

THE THEORY OF THE SHUNTED CONDENSER.

I.—Mathematical Treatment.

The following symbols will be used :—

V = voltage of fixed value suddenly applied to the circuit.

i = instantaneous current in the circuit at time t secs. after the application of V.

I = maximum steady current in the circuit.

E = maximum value of a sinusoidal E.M.F. applied to the circuit.

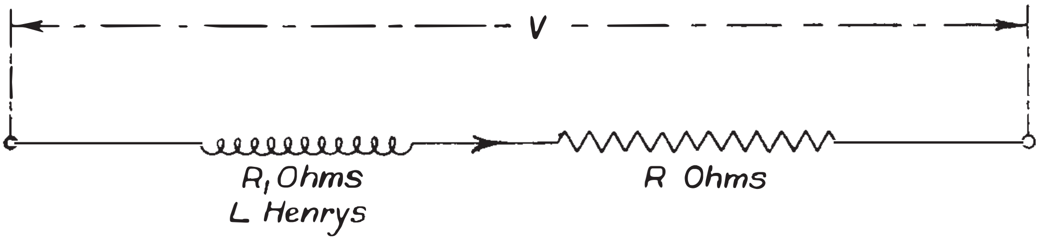
f = frequency in cycles per second.

ω = angular velocity in radians per second = $2\pi f$.

R_1 & L = resistance and inductance respectively of the receiver or relay.

R & C = resistance and capacity respectively of the shunted condenser.

FIG. II



If we consider, in the first place, the circuit shown in Fig. II the value of the current at any time t is given by :—

$$i = \frac{V}{R+R_1}\left\{1 - e^{-\left(\frac{R+R_1}{L}\right)t}\right\} = I\left\{1 - e^{-\left(\frac{R+R_1}{L}\right)t}\right\} \quad \ldots(1)$$

Formula (1) is proved in a number of text-books, for example, "Magnetism and Electricity," by H. E. Hadley, p. 431, 1905 edition.

The ratio $\frac{i}{I}\left[\text{which equals } 1 - e^{-\left(\frac{R+R_1}{L}\right)t}\right]$ has been calculated for various values of $(R+R_1)$ ohms, using an inductance L of 3.5 henrys, and the results are given in Table I, and are plotted on Fig. III. The value of L used in these curves is a reasonable average figure for the ballistic inductance of a Standard "B" Relay with coils in series.

TABLE I.

Time t secs.	Ratio $\frac{i}{I}$ when $(R+R_1)$ ohms is equal to						
	100	300	500	700	1000	2000	5000
0.001	0.028	0.082	0.133	0.181	0.249	0.436	0.761
0.002	0.056	0.158	0.249	0.330	0.436	0.681	0.943
0.003	0.082	0.227	0.349	0.451	0.576	0.820	0.986
0.004	0.108	0.290	0.436	0.551	0.681	0.898	0.997
0.005	0.134	0.349	0.511	0.632	0.760	0.943	
0.008	0.204	0.496	0.681	0.798	0.898	0.990	
0.010	0.249	0.576	0.760	0.865	0.943	0.997	
0.015	0.349	0.724	0.883	0.950	0.986		
0.020	0.436	0.820	0.943	0.982	0.997		
0.025	0.510	0.883	0.972	0.993			
0.030	0.576	0.923	0.986	0.998			

From these tabulated figures and the corresponding graphs it will be seen that the rate of rise of the current in a circuit of constant inductance steadily increases with an increase of the resistance of that circuit. The voltage necessary to establish the required maximum steady current is directly proportional to the total resistance of the circuit. If there were no limit to the value of the voltage V then the current in the circuit shown in Fig. II could be made to rise as quickly as required to a definite maximum value by simply increasing the value of R.

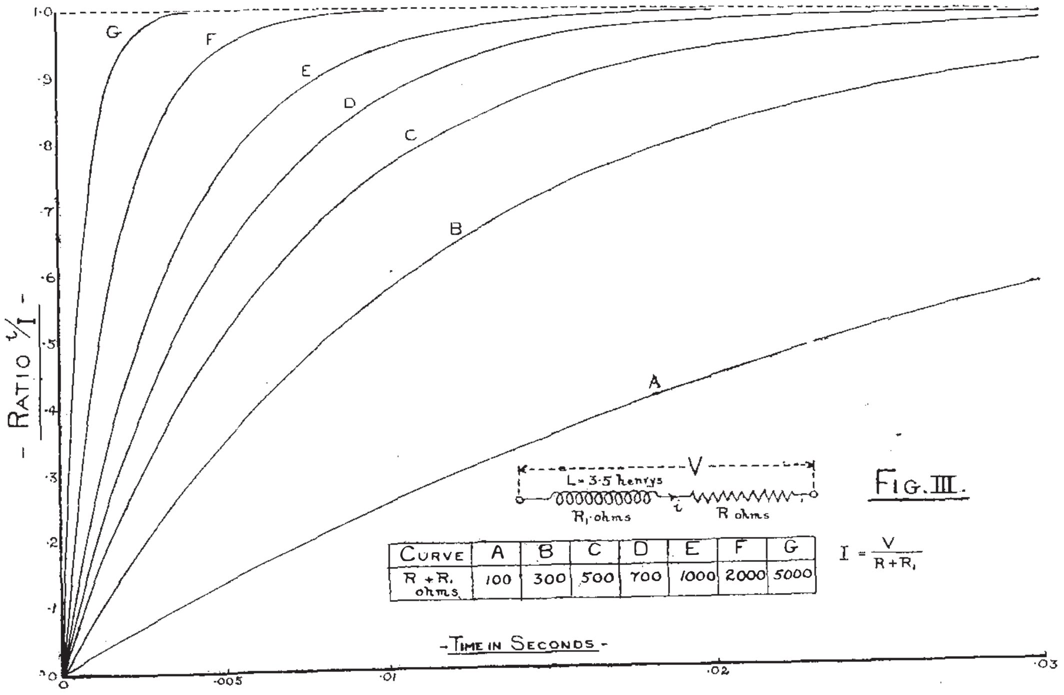


FIG. III.

CURVE	A	B	C	D	E	F	G
R + R, ohms	100	300	500	700	1000	2000	5000

$$I = \frac{V}{R+R_1}$$

In practice, however, V has a definite limit so that there is a maximum value beyond which R cannot be increased; if with this value of R the rate of rise of the current is not sufficiently rapid then it can be improved by shunting R with a capacity, and this improvement will be effected without altering the value of the maximum steady current.

Consider next the circuit shown in Fig. IV. The value of the current i at any time t is not, as far as the writer is aware, published in any technical literature and is therefore developed here.

The periodic solution is :—

$$i = \frac{Ee^{j\omega t}}{R_1 + j\omega L + \frac{1}{G + j\omega C}} \text{ where } G = \frac{1}{R}$$

Let $y = j\omega$

and $\phi(y) = R_1 + yL + \dfrac{1}{G + yC}$

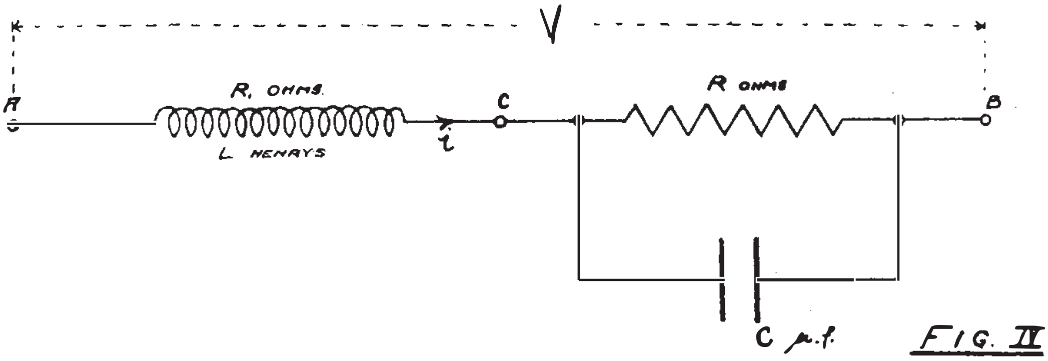


FIG. II

Then the transient solution is :—

$$i = \frac{V}{\phi(0)} + \frac{Ve^{yt}}{y\phi'(y)}$$

where y is obtained from the equation $\phi(y) = 0$

and $\phi'(y) = \dfrac{d}{dy}\,[\phi(y)]$

Now $\phi(0) = R_1 + \dfrac{1}{G} = R_1 + R$

and $\phi'(y) = L - \dfrac{C}{(G + yC)^2}$

To find the value of $y\ \phi'(y)$ it is necessary to find y from $\phi(y) = 0$.

If $R_1 + Ly + \dfrac{1}{G + yC} = 0$

$$\text{then } y = -\left(\frac{R_1}{2L} + \frac{G}{2C}\right) \pm \sqrt{\left(\frac{R_1}{2L} - \frac{G}{2C}\right)^2 - \frac{1}{LC}}$$

$$= -\alpha \pm \beta \text{ (say).}$$

Two values of $y\,\phi'(y)$ will consequently be obtained according as y is equal to $(-\alpha+\beta)$ or $(-\alpha-\beta)$ and these two values are $\dfrac{2L\beta(R+R_1)}{(R+R_1)-L(\alpha+\beta)}$ and $\dfrac{2L\beta(R+R_1)}{L(\alpha-\beta)-(R+R_1)}$ respectively.

The complete transient solution is therefore :—

$$i=\frac{V}{R+R_1}+V\left\{\frac{e^{(-\alpha+\beta)t}}{\dfrac{2L\beta(R+R_1)}{(R+R_1)-L(\alpha+\beta)}}-\frac{e^{(-\alpha-\beta)t}}{\dfrac{2L\beta(R+R_1)}{(R+R_1)-L(\alpha-\beta)}}\right\}$$

$$\text{or}\quad i=\frac{V}{R+R_1}\left\{1+e^{-\alpha t}\left[\frac{(R+R_1)-L(\alpha+\beta)}{2L\beta}e^{+\beta t}-\frac{(R+R_1)-L(\alpha-\beta)}{2L\beta}e^{-\beta t}\right]\right\}\qquad\ldots\ldots\ldots\ldots(2)$$

where $\alpha=\left(\dfrac{R_1}{2L}+\dfrac{G}{2C}\right)$

and $\beta=\sqrt{\left(\dfrac{R_1}{2L}-\dfrac{G}{2C}\right)^2-\dfrac{1}{LC}}$; also $I=\dfrac{V}{R+R_1}$.

By using equation (2) the value of $\dfrac{i}{I}$ can be calculated for any value of t if R_1 L G and C have definite values. A series of such calculations has been made and is given in Table II, taking $L=3.5$ henrys, $R_1=300$ ohms, $R=700$ ohms, and $C=$ various values.

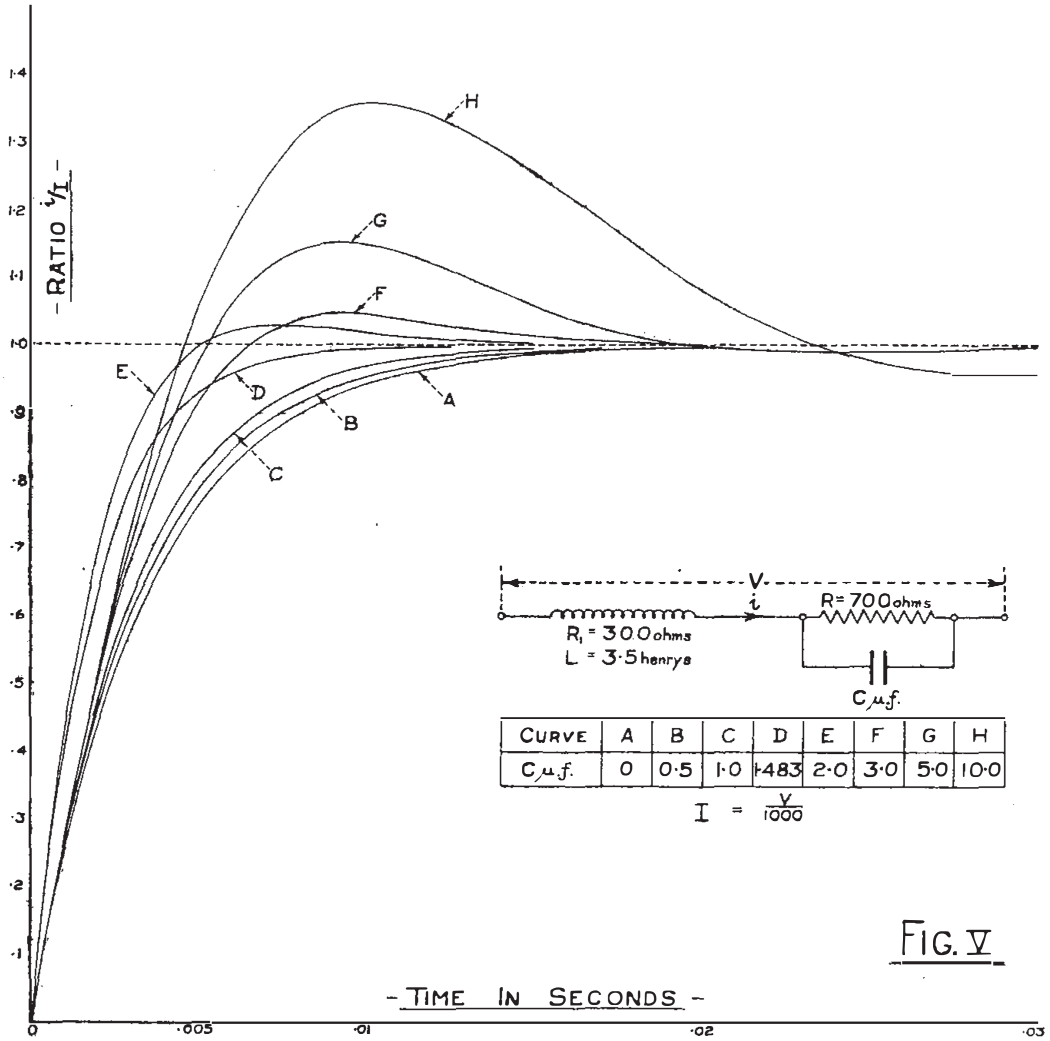
TABLE II.

$R=700$ ohms. $R_1=300$ ohms. $L=3.5$ henrys.

Time t secs.	Ratio $\frac{i}{I}$ when C $\mu.f.$ is equal to							
	0	0.5	1.0	1.483	2.0	3.0	5.0	10.0
0.001	0.249	0.260	0.264	0.408	0.421	0.271	0.271	0.273
0.002	0.436	0.457	0.473	0.650	0.690	0.499	0.508	0.515
0.003	0.576	0.605	0.626	0.793	0.854	0.681	0.704	0.727
0.004	0.681	0.709	0.736	0.877	0.947	0.818	0.860	0.905
0.005	0.760	0.786	0.814	0.927	0.997	0.915	0.977	1.050
0.008	0.898	0.915	0.935	0.985	1.027	1.037	1.140	1.306
0.010	0.943	0.954	0.968	0.995	1.018	1.045	1.148	1.357
0.015	0.986	0.990	0.994		1.002	1.013	1.058	1.255
0.020	0.997	0.998			1.000	1.000	0.998	1.080
0.025					1.000	0.999	0.990	0.979
0.030					1.000	1.000	0.997	0.959

The figures given in Table II have been plotted in Fig. V. From these curves it will be seen that the rate of rise of the current in the circuit increases as C is increased until when $\beta=0$

a critical value of C is reached, which in this particular case is 1.483 $\mu.f.$ If C be still further increased the instantaneous current will rise above its maximum steady value and then oscillate about this value until the oscillation is damped out. The larger C is now made, the greater the maximum transient current value becomes. These curves assume fixed values of R_1 and L for the resistance and the inductance; as these values vary considerably with frequency and testing current in the case of a Wheatstone Receiver



CURVE	A	B	C	D	E	F	G	H
$C\mu.f.$	0	0·5	1·0	1·483	2·0	3·0	5·0	10·0

$I = \frac{V}{1000}$

FIG. V

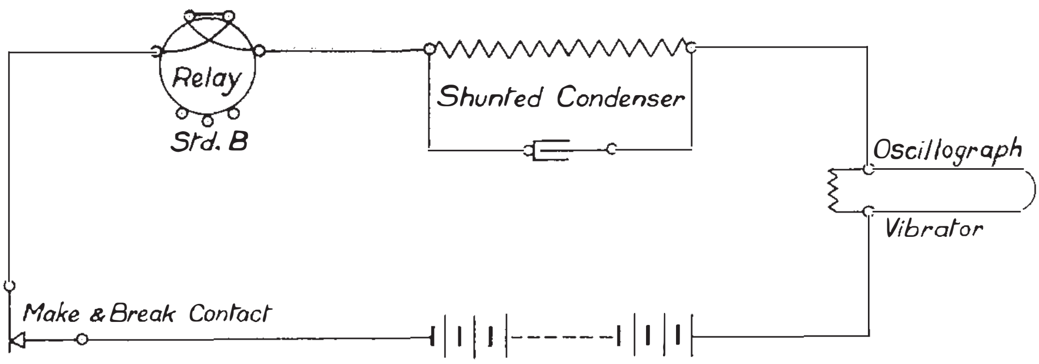
or a Standard " B " Relay it is not possible to reproduce these curves exactly in practice. But it will be seen from several oscillograph records which will now be shown that a similar set of curves is actually obtained under practical conditions.

II.—OSCILLOGRAPH CURVES.

A series of curves was taken by means of the oscillograph in order to show the actual effect of a shunted condenser on the rise of current in a Standard " B " Relay when a voltage is suddenly applied to the circuit. The connections employed are shown in Fig. VI, and the curves are shown in Figs. VII*a* and VII*b*.

In all these records, with the exception of No. IX, the value of R was fixed at 700 ohms; the condenser values were increased from 0 to 10 μ.*f*. as shown in Table III which follows. Curve No. IX shows the rise of current given in Fig. VI, when C and R are both zero. By comparing this last curve with No. I of the series it will be seen clearly that by adding non-inductive resistance alone in series with the relay the rate of rise of the current in its coils has been appreciably increased.

FIG. VI

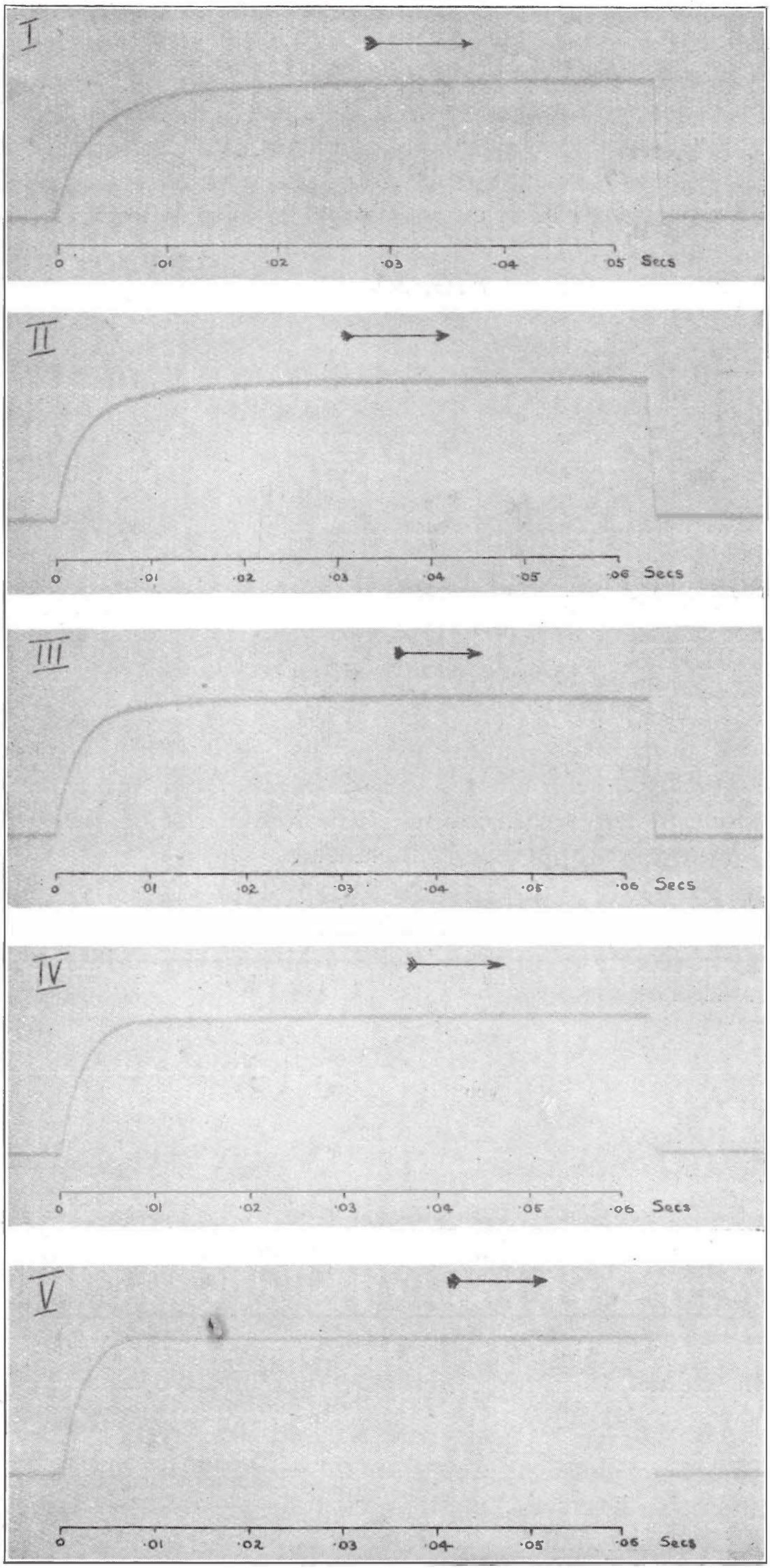


Voltage adjusted to give a steady Current of 30 m.A.

TABLE III.

Oscillograph Curve No.	Shunted Condenser Values. R ohms.	Shunted Condenser Values. C μ.*f*.	Maximum steady current in m.a.
I.	700	0	30
II.	,,	1	,,
III.	,,	2	,,
IV.	,,	3	,,
V.	,,	4	,,
VI.	,,	5	,,
VII.	,,	8	,,
VIII.	,,	10	,,
IX.	0	0	,,

The values of $\frac{i}{I}$ for different values of t have been obtained from these curves by measurement and are given in Table IV. By comparing these figures with those given in Table II a fair agreement is observed, but it would not appear to be possible for any figures calculated with fixed values of R_1 and L to agree


I
0
·01
·02
·03
·04
·05 Secs
II
0
·01
·02
·03
·04
·05
·06 Secs
III
0
·01
·02
·03
·04
·05
·06 Secs
IV
0
·01
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V
0
·01
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Fig. VII *a.*

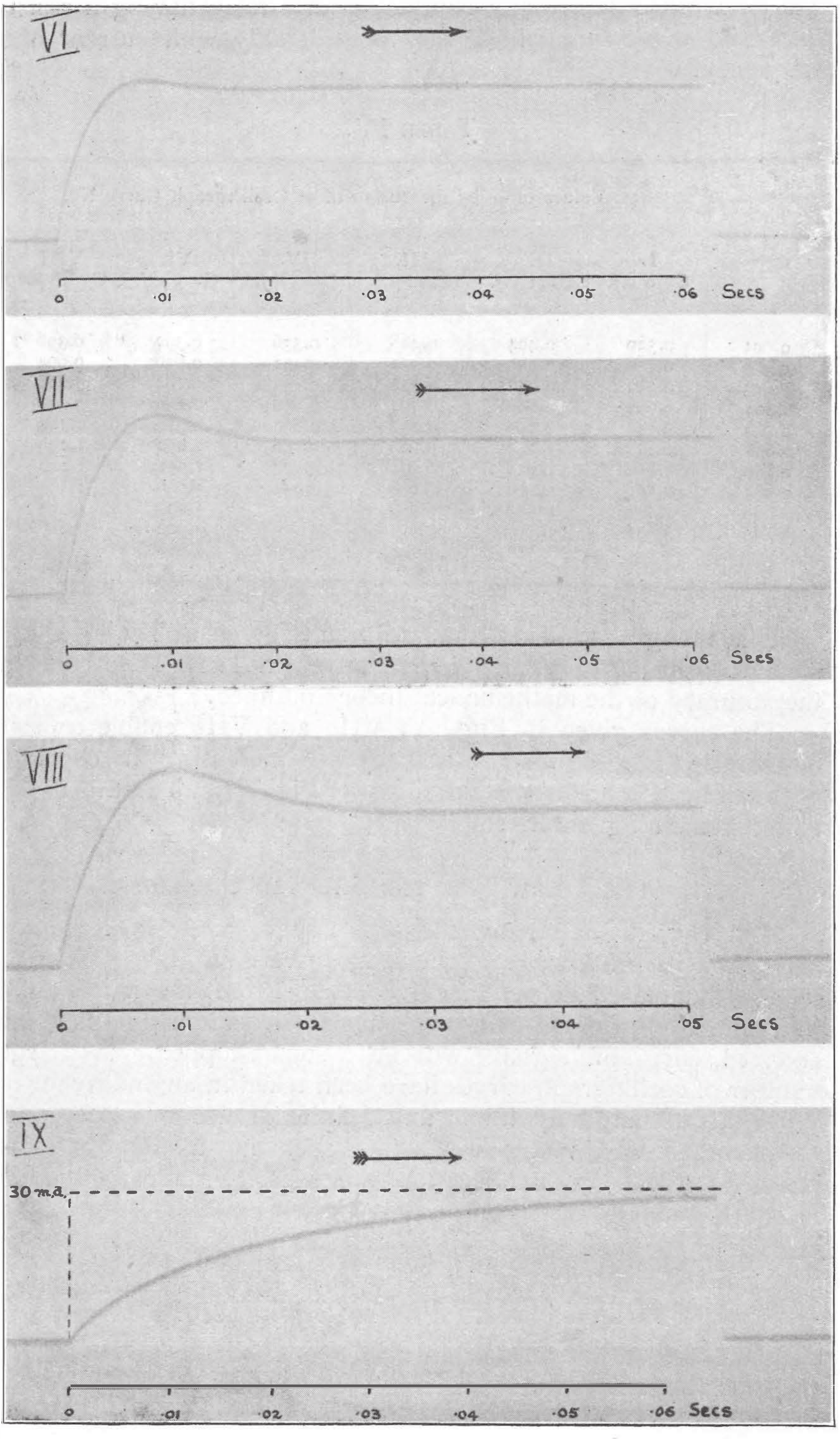

VI
0
·01
·02
·03
·04
·05
·06
Secs
VII
0
·01
·02
·03
·04
·05
·06
Secs
VIII
0
·01
·02
·03
·04
·05
Secs
IX
30 m.a.
0
·01
·02
·03
·04
·05
·06
Secs

Fig. VII *b*.

exactly with those actually obtained with a relay having a resistance and inductance which vary considerably with current and frequency.

TABLE IV.

Time t secs.	Values of $\frac{i}{I}$ by measurement of Oscillograph Curve No.					
	I. $C=0$ $\mu.f.$	II. $C=1$ $\mu.f.$	III. $C=2$ $\mu.f.$	IV. $C=3$ $\mu.f.$	VI. $C=5$ $\mu.f.$	VIII. $C=10$ $\mu.f.$
0.001	0.320	0.404	0.428	0.356	0.392	0.396
0.002	0.488	0.592	0.592	0.592	0.620	0.604
0.003	0.592	0.688	0.712	0.732	0.784	0.828
0.004	0.660	0.760	0.792	0.836	0.898	0.972
0.005	0.732	0.808	0.832	0.890	0.976	1.104
0.008	0.872	0.896	0.920	0.960	1.076	1.290
0.010	0.912	0.928	0.952	0.976	1.051	1.290
0.015	0.960	0.968	0.980	0.992	1.000	1.164
0.020	0.980	0.988	0.999	0.999	1.000	1.060
0.025	0.992	0.999			1.000	1.016
0.030	0.999				1.000	1.000

It is thought, however, that the results given in Table IV are sufficiently in agreement with those given in Table II to confirm the accuracy of the mathematical theory outlined.

The curves given in Figs. V, VII*a* and VII*b* enable a clear mental picture to be made of the effect of increasing the capacity of the shunted condenser in the circuit of Fig. VI, other parts of the circuit remaining unaltered.

III.—THE "LAW" OF THE SHUNTED CONDENSER.

Referring to the circuit shown in Fig. I, it has been stated[*] that when the inductance of the relay or receiver (L) is balanced by the shunted condenser then $L=CR^2$. From this statement it has generally been assumed that when this relationship exists the received telegraph signals will be "square-topped." A large number of oscillograph curves have been taken in an endeavour to prove this assumption without any definite success.

In order to investigate whether such an assumption was justified the following mathematical and experimental investigation has been made:—

(*a*) *Mathematical Investigation of the Problem.*

If an alternating voltage, frequency $= \frac{\omega}{2\pi}$, be applied at the terminals AB of the circuit shown in Fig. IV, then the current in the circuit will be in phase with this voltage if a certain condition is satisfied. This condition may be obtained as follows:—

---

[*] See "Telegraphy," by T. E. Herbert, p. 315, 1906 edition.

$$\text{Impedance AC} = R_1 + j\omega L$$

$$\text{,, } \quad CB = \frac{jR}{j - \omega RC}$$

$$\therefore \text{Impedance AB} = R_1 + j\omega L + \frac{jR}{j - \omega RC}$$

$$= R_1 + j\omega L - \frac{jR(j + \omega RC)}{1 + \omega^2 R^2 C^2}$$

$$= \frac{(R_1 + j\omega L)(1 + \omega^2 R^2 C^2) - jR(j + \omega RC)}{1 + \omega^2 R^2 C^2}$$

$$= \frac{R_1 + R + \omega^2 R_1 R^2 C^2 + j(\omega L + \omega^3 L R^2 C^2 - \omega R^2 C)}{1 + \omega^2 R^2 C^2}$$

If the current is in phase with the voltage in this impedance then it follows that:—

$$\omega L + \omega^3 L R^2 C^2 - \omega R^2 C = 0$$

Hence $\omega = 0$ or $L + \omega^2 L R^2 C^2 - R^2 C = 0$

$$\textit{i.e.,} \quad CR^2(1 - \omega^2 LC) = L$$

$$\therefore CR^2 = \frac{L}{1 - \omega^2 LC} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Condition (3) must be satisfied if the impedance AB is to be non-reactive when the applied voltage has a frequency of $\frac{\omega}{2\pi}$.

Now if telegraph reversals applied to the circuit AB are to be exactly "square-topped" it follows that this circuit must be non-reactive to currents of all frequencies which are present in these signals. It is necessary, therefore, to consider what frequencies are present in telegraph reversals. The current curve of such signals, neglecting the short period of break between marking and spacing currents, is shown in Fig. VIII, and the equation to this curve is:—

$$y = \sin \omega t + \tfrac{1}{3} \sin 3\omega t + \tfrac{1}{5} \sin 5\omega t + \tfrac{1}{7} \sin 7\omega t + \tfrac{1}{9} \sin 9\omega t + \ldots\ldots\ldots (4)$$

where y represents the current at any time t, and $y = 0$ when $t = 0$.

It will be seen from equation (4) that (*a*) there are an infinite number of frequencies included in the current shown in Fig. VIII, and (*b*) if the magnitude of the current of the fundamental frequency be represented by unity, the magnitudes of the currents of the third, fifth, seventh, etc., harmonics are represented respectively by $\frac{1}{3}$, $\frac{1}{5}$, $\frac{1}{7}$, etc.

It is next necessary, using the information given by formulæ (3) and (4), to ascertain under what conditions the circuit shown in Fig. IV will be non-reactive when the telegraph signals shown in Fig. VIII are sent through it. In order to make this investigation assume a telegraphic speed of 60 words per min., corresponding to a fundamental frequency of 24 cycles per sec. The inductance of a certain Standard " B " Relay, between the limits—

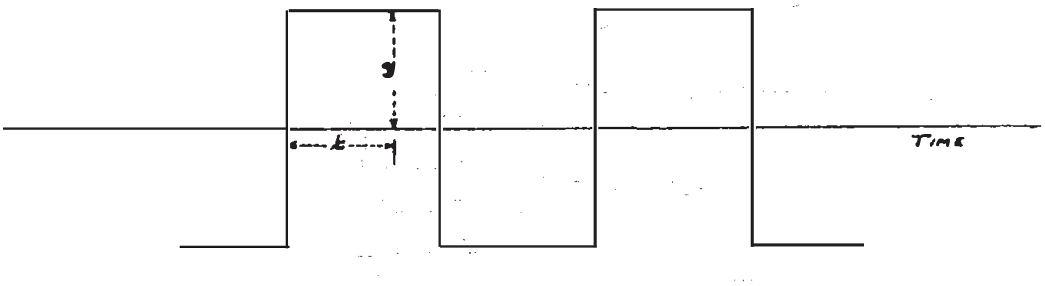


FIG. VIII

24 cycles per sec. with 20 m.a.
and 984 ,, ,, ,, 0.49 m.a.

was measured and the results are given in Fig. IX (Curve E). The testing currents in m.a.'s at the intermediate frequencies were equal to $\frac{20 \times 24}{f}$ *i.e.* $\frac{480}{f}$ in order to satisfy the current law given in equation (4). Now using formula (3) the values of L can be calculated for various values of ω and C, assuming CR^2 is a constant. This constant, when $\omega = 0$, is equal to L, which is the inductance of the relay obtained by d.c. or ballistic test. In the case of the relay under consideration the ballistic L, with a current of 20 m.a., was found to be 3.9 henrys. The results of the calculations for L are given in Table V which follows :—

TABLE V.

f	ω	Value of $L = \frac{3.9}{1+3.9\omega^2 C}$, when C in $\mu.f.=$							
		0.10	0.25	1.0	2.0	3.0	4.0	5.0	6.0
0	0	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
24	151	3.87	3.82	3.50	3.32	3.10	2.90	2.72	2.57
72	453	3.61	3.25	2.17	1.50	1.15	0.928	0.780	0.672
120	755	3.19	2.51	1.21	0.717	0.509	0.395	0.322	0.272
168	1057	2.72	1.87	0.728	0.402	0.277	0.212	0.171	0.144
216	1359	2.27	1.39	0.476	0.253	0.173	0.131	0.105	0.088
264	1661	1.88	1.06	0.332	0.173	0.117	0.089	0.071	0.060
360	2265	1.30	0.650	0.186					
504	3171	0.793	0.360	0.097					
744	4681	0.409	0.175						
984	6191	0.244	0.102						

The variation of L with frequency given in Table **V**, for four of the values of C assumed, has been plotted on Fig. IX, Curves A, B, C and D. These four curves give, for any value of C, the variation of the inductance of the relay with frequency in order that the circuit, Fig. IV, may be non-reactive to telegraph reversals when CR^2 is constant and equal to 3.9.

Although the figures given in Table V have been calculated using a fundamental frequency of 24 cycles per second (corresponding to 60 words per minute) yet the same values will be obtained for any assumed speed of the telegraph reversals, if CR^2 is equal to 3.9.

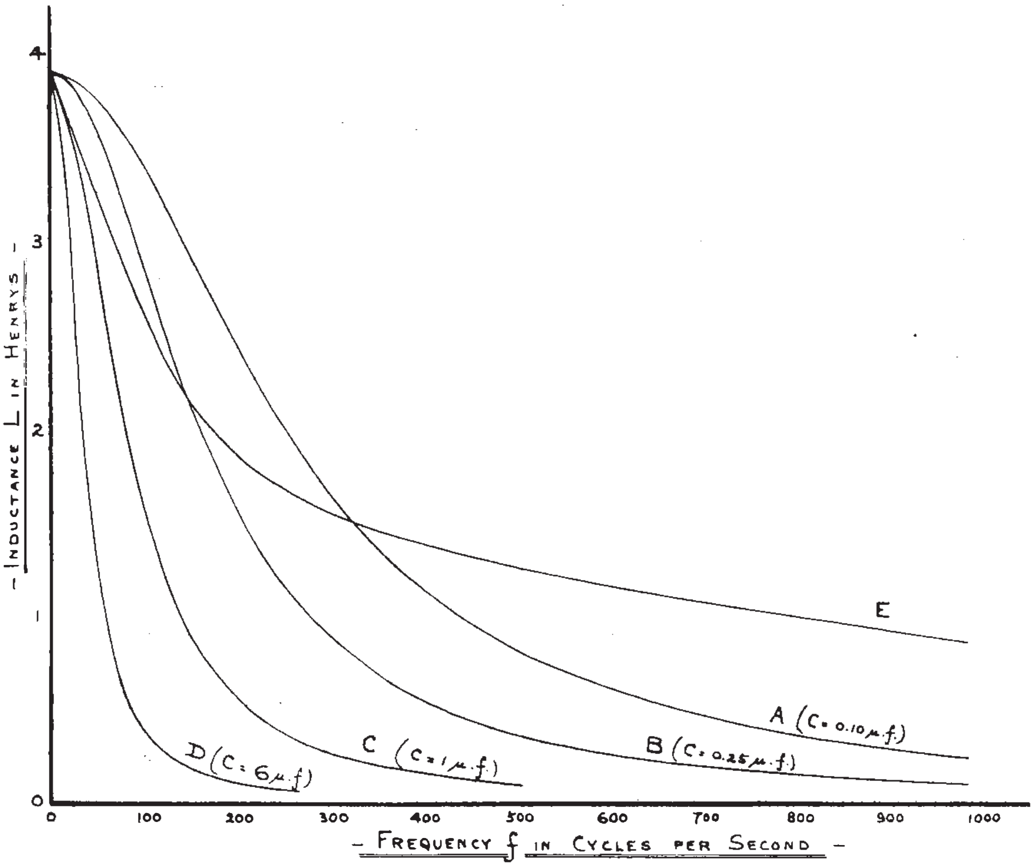


FIG. IX.—VARIATIONS OF INDUCTANCE WITH FREQUENCY.

The curve E, however, is an experimental one and is only correct for the particular relay tested and with the testing currents in accordance with the law stated.

From the curves given on Fig. IX, the following deductions can be made :—

(1) Using the Standard " B " Relay before-mentioned and a fixed value of CR^2, no value of C can be found which will make the circuit shown in Fig. IV exactly non-reactive when telegraph reversals at 60 words per minute (maximum current = 20 m.a.) are

being received. It will also be seen that with small values of capacity C and consequently large values of R the circuit Fig. IV is more nearly non-reactive to the telegraph reversals than when large values of C and small values of R are used.

(2) With any given relay or receiver there is, at most, only one value of C (assuming CR^2=constant) which will make the circuit shown in Fig. IV truly non-reactive to telegraph reversals. This condition occurs when curve E is coincident with a curve such as A, B, C or D, Fig. IX. This means that exact " square-topped " reversals can only be obtained with, at most, one value of C if CR^2 is constant.

(3) If a value of CR^2 other than 3.9 be used for a series of curves such as A, B, C and D, they will not coincide with E when the frequency is zero.

By using the values of L given by the curve E, Fig. IX, and assuming CR^2 equal to 3.9 say, it is possible to calculate the values of C which will satisfy the equation (3) for different frequencies. In Table VI are given the calculated values of C for the different frequencies, up to the 41st harmonic, contained in telegraph reversals corresponding to a speed of 60 words per minute.

TABLE VI.

$$C = \frac{3.9 - L}{3.9\omega^2 L}$$

f	ω	L hys. (See curve E, Fig. IX.).	C $\mu.f.$
24	151	3.55	0.111
72	453	2.90	0.450
120	755	2.37	0.290
168	1057	2.00	0.218
216	1359	1.74	0.173
264	1661	1.58	0.137
312	1961	1.48	0.109
360	2265	1.41	0.088
504	3171	1.24	0.055
744	4681	1.04	0.032
984	6191	0.85	0.025

From the foregoing it appears evident that if, by a coincidence, exact " square-topped " telegraph reversals are obtained in a Standard " B " Relay or Wheatstone Receiver by placing a shunted condenser in series with it, then only one value of C with the corresponding value of R will effect this. No such law as $CR^2 = L$ or some constant appears to apply.

In actual telegraph working, however, the shunted condenser will function satisfactorily provided that it causes the current in the relay coils to rise to its maximum value within a certain time. This time, t, which will depend on the speed of working, should not exceed the time occupied by a dot signal. With a telegraph speed of 400 words per minute a dot signal occupies $\frac{1}{320}$ or 0.0031 second.

Oscillograph curves show that if the time t be reduced to a very small value by means of a shunted condenser, using the circuit shown in Fig. IV, the shape of the telegraph signal will generally be similar to that shown in Fig. X. This type of signal is usually considered to be ideal, as the initial excess of current will result in a quick movement of the relay contact arm from one stop to the other and the steady value will then hold the arm firmly on the working contact.

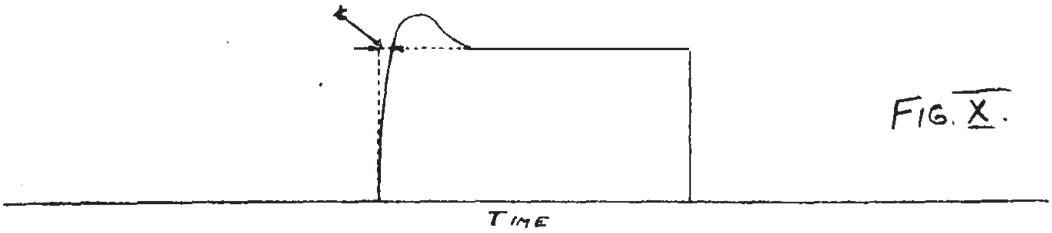


FIG. X.

Some investigations have recently been made to determine the inductance of a Standard " B " Relay with different currents and frequencies. It is thought that these may prove a useful addition to this section of this article and they are, therefore, included here.

(*b*) *The variation of inductance of a Standard " B " Relay with variation of current and frequency.*

The following experiments, selected from a number which have been made, will suffice to show how variable is this inductance with different conditions of test:—

(1) Six Standard " B " Relays were obtained and the resistance and inductance of each of them measured, using an alternating current of 4.5 m.a. (R.M.S.) of a frequency of 50 cycles per second. The figures obtained, with coils in series, were as given in Table VII.

TABLE VII.

Relay Sample No.	1	2	3	4	5	6
Effective Resistance in ohms ...	475	522	495	540	511	485
Inductance in henrys	3.50	2.90	2.60	3.65	3.00	3.35

These results show that, under the same conditions of test, there was as much as 1.05 henrys difference in inductance between two of the relays; the maximum difference in effective resistance of these relays, under the same conditions of test, was 65 ohms.

(2) The inductance of a selected relay, coils in series, was measured with frequencies from 0 to 160 cycles per second, and currents from 1 to 25 m.a. Table VIII gives the experimental results.

TABLE VIII.

INDUCTANCE OF STANDARD "B" RELAY, COILS IN SERIES.

Frequency f	Testing current in m.a.						
	1.0	3.0	4.5	10	15	20	25
0 (Ballistic Test)	2.64	3.21	3.47	3.69	3.85	3.88	3.90
12	2.35	2.66	2.76	3.09	3.23	3.39	3.51
25.5	1.96	2.34	2.48	2.97	3.20	3.27	3.32
52.5	1.64	1.92	2.11	2.72	2.90	2.97	3.01
71.5	1.47	1.75	1.97	2.56	2.74	2.79	2.81
100	1.27	1.55	1.74	2.36	2.43	2.50	2.53
134	1.17	1.37	1.62	2.22	2.36	2.38	2.36
160	1.08	1.29	1.50	2.08	2.23	2.25	2.22

The inductance in Table VIII varies from 3.90 henrys (ballistic test with 25 m.a.) to 1.08 henrys (frequency of 160 cycles per second with 1 m.a.). This latter frequency is the fundamental one for telegraph reversals corresponding to 400 words per minute.

As an interesting comparison the inductance of the same relay, coils in parallel, with a current of 4.5 m.a. is given in Table IX.

TABLE IX.

INDUCTANCE OF STANDARD "B" RELAY, COILS IN PARALLEL AND A TESTING CURRENT OF 4.5 M.A.

Frequency (f)	0 (Ballistic test).	11.0	26.4	50.0	75.7	81.6	102	134	167
Inductance in Henrys	0.775	0.653	0.501	0.453	0.384	0.360	0.324	0.297	0.262

The figures given in Table VIII (current 4.5 m.a.) and also those given in Table IX are plotted on Fig. XI.

IV.—CONCLUSIONS.

(a) The effect of the shunted condenser, shown in Fig. I, is to reduce the time taken by the current to reach the maximum value due to a suddenly applied constant voltage. The exact effect with different values of R and C may be studied by means of formula

(2) if R_1 and L are fixed values; using a Standard " B " Relay the rise of current curves will only approximate more or less to those given by (2) on account of the variation of R_1 and L with current and frequency.

(*b*) In order that telegraph reversals applied to the circuit shown in Fig. I may be exactly "square-topped," this circuit

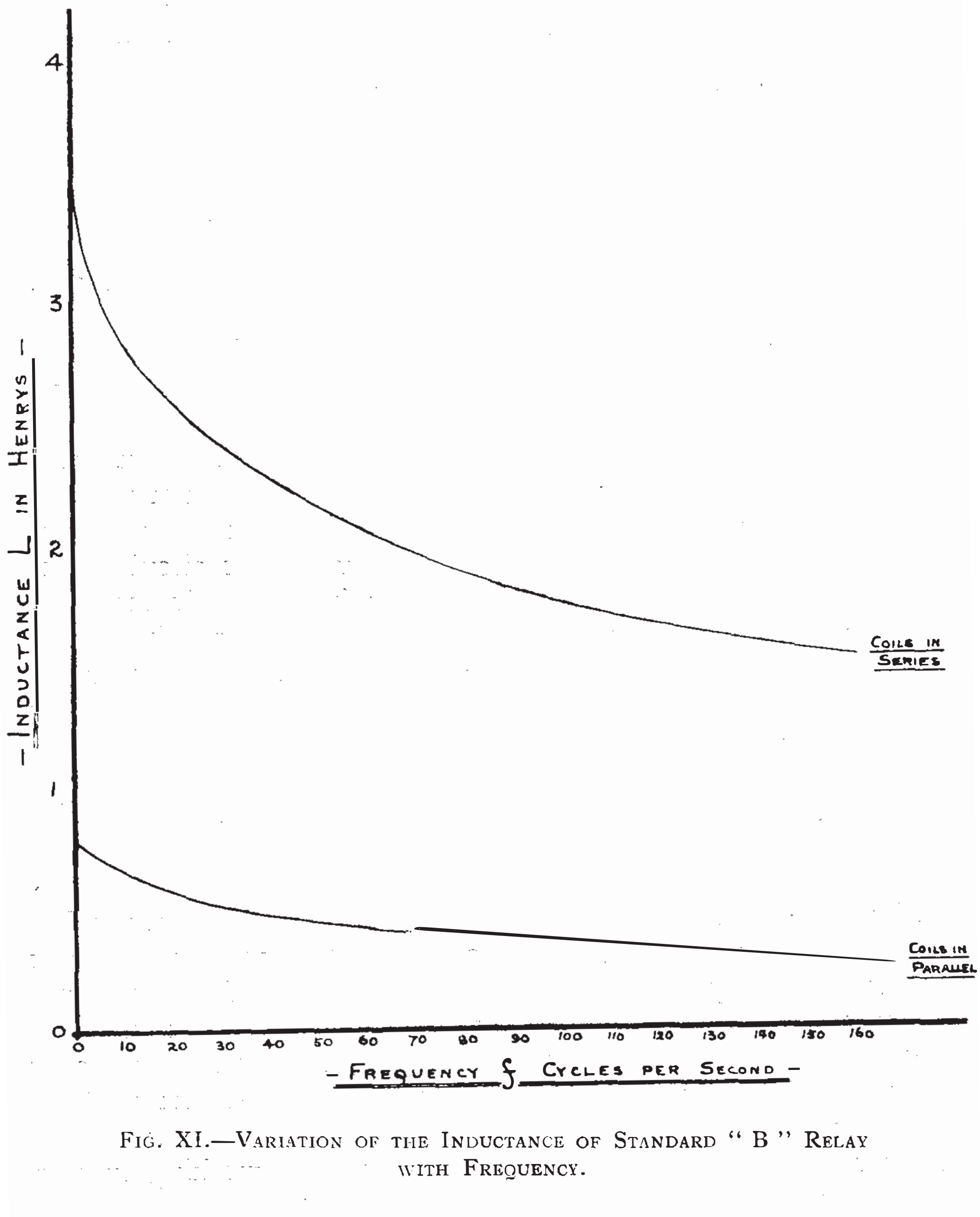


Fig. XI.—Variation of the Inductance of Standard " B " Relay with Frequency.

must be non-reactive to such signals. It can be proved mathematically that (1) this condition cannot be satisfied, if CR^2 is a constant, for more than one value of C with the corresponding value of R and (2) if this condition be satisfied it is a coincidence. In order that the current may rise to its maximum sufficiently quickly for high speed working, oscillograph curves show that the shape of the signal in this circuit will usually be of the type shown in Fig. X.

(*c*) The inductance of a Standard "B" Relay varies considerably with the testing current and frequency, See Tables VIII and IX.

(*d*) The conclusions already enumerated are considered to apply equally to a Wheatstone Receiver or a Standard "B" Relay, as the coils and magnetic circuit of both instruments are of the same design.

ALARMS, REPEATER, No. 3.

AT telegraph repeater stations the sounders which form part of the repeater sets are, as a rule, normally kept out of circuit. In such cases a means whereby the other stations on the circuit can gain the attention of the repeater station is provided. The arrangement at the latter point has been changed from time to time, but the procedure at the other points has never varied; a marking current is sent to line through an interval of 20 seconds. This results in an audible signal at the repeater station; either the appropriate sounders are automatically brought into circuit or the signal takes the form of a ring on a trembler bell; in the latter case the sounders are switched in by hand. Formerly the calling apparatus at the repeater station was comprehended under the term "Sounder Silencer." The subject was dealt with in an article by Mr. J. J. Hardie in the July, 1919, issue of this Journal. Since then the term "Sounder Silencer" has been displaced by that of the "Alarm Repeater," principally for the reason that attention is attracted by the ringing of a bell.

The basis of the action of the "Sounder Silencer No. 3," the "Alarm Repeater No. 1," and also of the "Alarm Repeater No. 3," which is now being introduced, is the slow charging of a condenser through the 20 seconds period, followed by the direct discharge of the condenser through the alarm indicator or relay. That is to say, the charge accumulated in 20 seconds is sufficient to actuate the indicator or relay, with a reasonable margin over. A 15 seconds charge, for instance, or anything less, should fail. The alarm is therefore unaffected by the ordinary working currents of the circuit.

The theory underlying the charging and discharging may be briefly stated thus: the equation of electro-motive forces for a battery of voltage v joined in series with a condenser of capacity c, a resistance r and an inductance l is:—

$$l\frac{d^2q}{dt} + r\frac{dq}{qt} + \frac{q}{c} = v \quad \text{......................................(1)}$$

q being the instantaneous value of the accumulated charge. If l and r are small, as in the ordinary case of connecting a condenser direct to a battery, the first and second terms in (1) may be rejected, reducing that statement to the well-known and explicit form :—

$$\frac{q}{c} = v \quad \text{..(2)}$$

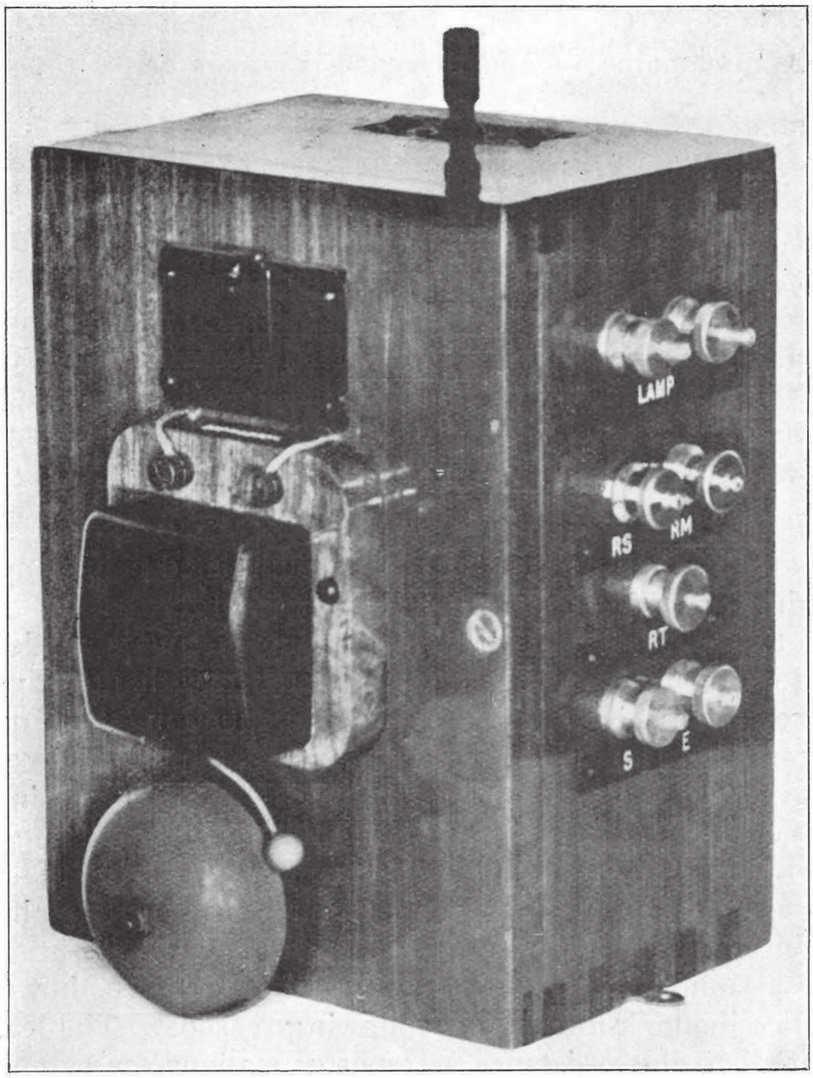


Fig. 1.—Alarm, Repeater, No. 3.

The condenser becomes fully charged instantaneously.

When a resistance r is interposed between the battery and condenser in the above case the rate of charging is decreased. The equation is now :—

$$r\frac{dq}{dt} + \frac{q}{c} = v \quad \text{...(3)}$$

At the moment of completing the circuit the value of $\frac{q}{c}$ is zero and that of $r\frac{dq}{dt}$ is v. With the passage of current a charge accumulates, so that $\frac{q}{c}$ increases and $r\frac{dq}{dt}$ decreases until, when the condenser is fully charged, $\frac{q}{c}$ equals v, as before, and $r\frac{dq}{dt}$, that is, $\frac{dq}{dt}$, is zero. In short, the charging current $\frac{dq}{dt}$ starts with the maximum value $\frac{v}{r}$ and decreases towards zero; time enters into the charging process.

The solution to (3) is:—

$$q_t = cv\left(1 - \epsilon^{-\frac{t}{cr}}\right) \quad \text{.........} (4)$$

where q_t is the accumulated charge after t seconds and cv is the final steady charge. The product cr is, of course, the time constant of the circuit and as such constitutes a basis or standard for the few necessary calculations in the present case. For if t is made numerically equal to the product cr in (4) that statement simplifies to:—

$$q_t = \cdot 634\, cv \quad \text{.........} (5)$$

That is, in time t equal to cr the accumulated charge amounts to roughly two-thirds of the final steady charge.

On the assumption that the charging circuit is made up of the battery, condenser and a pure resistance without inductance, the procedure now is simple. Employing equation (2) the quantity q is ascertained by experiment that will just actuate with certainty the relay or indicator it is proposed to use. Replace q_t in (5) by the value of q just found and so obtain the value of the slowly charged condenser c, v having the same value as in the experimental application of (2). It only remains to ascertain the value of r from the relation $t = cr$, which was made the basis of (5).

The assumption as to the absence of inductance, however, is in practice inadmissible for the following reasons. The lead from the battery to the resistance at repeater stations, as at any large telegraph station, is very probably one of a number of wires in a lead-covered cable, the length of which may be anything from ten to thirty yards; the high resistance unit itself cannot be said to be non-inductive. It might be urged that the values of the inductances in the circumstances are small and negligible, but not when it is considered that the initial and maximum value of the charging current is no greater than of the order of ten microamperes. Now, any individual case might be met by applying the solution to equation (1) but for the fact that if the presence of inductance is admitted by reason of the contiguous conductors in the battery cable, it must also be admitted that that inductance varies with the number of contiguous conductors in use at any given moment.

The effect of any such inductance must be, by equation (1), to make the initial value of the charging current zero and to reduce its maximum value; the accumulation of charge q is delayed. Fortunately, it is only necessary to recognise the effect; the 20 seconds charging interval allows of a fair safety margin.

The Indicator No. 100A has been adopted for the Alarm Repeater No. 3, its coils being joined in parallel. This instrument can be actuated unfailingly by a 1 μf condenser charged direct from 80 volts (Equation 2). The appropriate condenser of C μf charged from the same voltage through a resistance of R ohms, the value of which is such that t equals C_fR, is 1.6 μf (Equations 4 and 5). C_f being stated in farads, R is at once seen to be 12.5 megohms.

This, however, leaves no safety margin whatever, even if the retarding inductance effect were not present. Actually, the stock 2 μf condenser is being used; taking this value for C and reducing t from 20 seconds to 15 gives the value of R as 7.5 megohms. From what has been learned from the limited trials it is expected the conditions generally will be met by the use of 6-megohm resistances.

A reference to Mr. Hardie's article will show that the idea of employing this method of calling repeater stations is by no means new. The idea itself is neat and appealing in its theory, but in those days practice failed, unfortunately, to support the theory in so far as it was difficult to obtain resistances having values suited to the stock instruments that the conditions demanded. Not only so, such resistances as were available were very inconstant. The position to-day is very much improved though not perfect. With a little trouble fixed resistances can be obtained which closely approximate to almost any stated value up to ten megohms. What is more important, selected types show very little variation with current, especially with the small maximum of ten micro-amperes or so used in the present case.

The new instrument is shown in Fig. 1 and a diagram of its wiring in Fig. 2. It will be seen that the audible alarm is supplemented by a visual signal in the shape of a lamp. The terminals RS, RT and RM on each side of the diagram are connected to the S, T and M terminals of the leak relay and receiver respectively of the repeater.

In investigating the subject recently a trial was made of a relay having a retaining connection. It was thought a relay would be preferable to use in place of a drop indicator for the

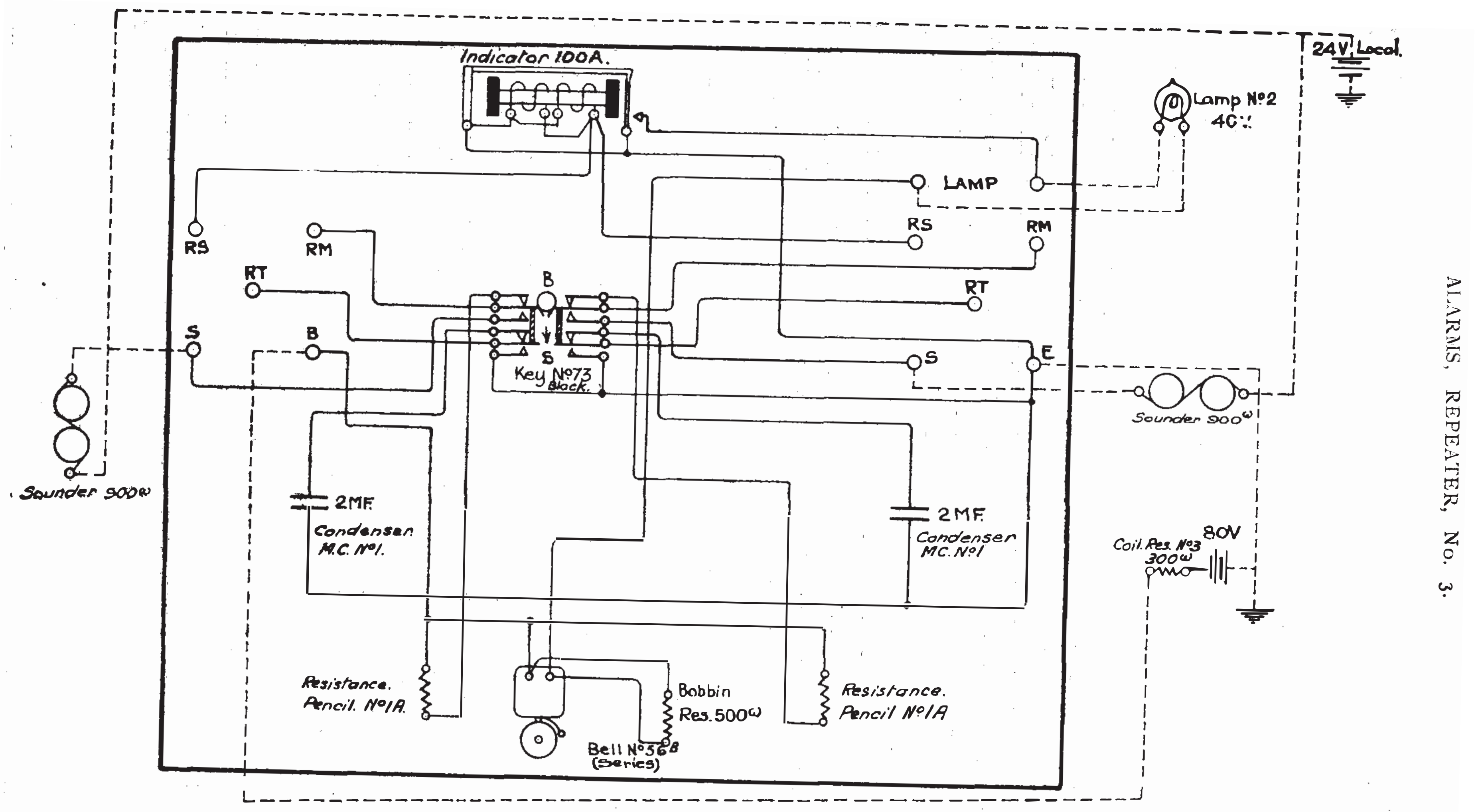


FIG. 2.—WIRING OF ALARM, REPEATER, No. 3.

reason that with the latter a cumulative action resulting in a false call might be exhibited. That is to say, if the signalling currents were such that charging periods of, say, five seconds or so were met with, any one of these charges, while insufficient by itself to actuate the drop definitely, might move the armature to a new position relatively to its shutter, *i.e.*, the trigger overlap would be reduced. Consequently, if this were repeated sufficiently often the indicator would ultimately be actuated. So far as experience has shown, the fears are unfounded. Nevertheless, the point may be mentioned as likely to interest the maintenance staff.

J.B.L.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES. THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST DECEMBER, 1924.

Telephone Stations.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
433,002	618	4,153	57,752	502	London	22,097	46,219	1,497,619	48,972
51,008	1,904	19,160	51,464	1,680	S. East	3,723	18,169	81,702	12,437
53,965	4,340	24,252	41,513	1,740	S. West	13,473	3,153	82,320	6,169
42,058	8,719	29,658	37,777	5,706	Eastern	13,688	20,285	42,526	26,005
73,794	8,592	40,957	49,137	3,383	N. Mid.	16,258	28,546	122,631	80,044
51,097	4,907	25,247	52,182	4,514	S. Mid.	10,452	12,948	99,551	83,768
48,552	5,100	27,600	42,771	1,970	S. Wales	5,304	13,410	71,682	24,326
76,328	8,551	23,223	40,503	4,838	N. Wales	11,818	28,155	134,927	44,414
121,089	3,006	16,692	46,554	3,384	S. Lancs.	12,259	55,139	300,380	42,368
72,643	6,282	28,763	42,840	2,833	N. East	7,901	22,354	145,865	24,926
47,868	3,890	23,614	38,132	2,026	N. West	7,587	26,792	91,759	20,971
38,069	2,539	15,111	23,217	2,103	North	2,740	8,256	59,910	7,383
17,308	4,784	5,821	11,122	246	Ireland N.	139	58	28,243	100
50,124	5,601	20,749	32,375	1,261	Scot. East	1,575	5,745	79,902	11,566
72,852	7,514	22,419	39,088	953	Scot. West	12,366	18,962	180,703	27,999
1,249,738	76,347	327,419	606,427	37,139	Totals.	141,380	308,191	3,019,720	461,448
1,219,323	76,960	321,916	598,072	35,468	Figures on 30th Sept., 1924.	139,184	288,446	2,954,003	452,936

MECHANICAL AIDS.

SOME ASPECTS OF "AUTOMATIC" TELEPHONE WORK.

By W. Wheeler.

In a brief and convincing article appearing in the July, 1920, issue of this Journal, Mr. B. O. Anson dealt with the dominating factors which have been responsible for the commencement of the era of "The Automatic Telephone." The article bases the case on the claims of "Service," and concludes with the statement: "*If the telephone man's ideal of Universal Service is to be attained, it is clear that he must employ a machine for switching.*"

Satisfactory Automatic Exchange Maintenance involves a fair number of routine operations on the considerable number of automatic units which go to make up a telephone exchange. To entrust the care of these operations to "the machine" would, in the opinion of the writer, not only relieve the manual staffs of unwanted duties (thereby promoting "Manual" efficiency) but lead to their performance with increased speed and efficiency.

The considerable number of circuit diagrams and switching arrangements developed during recent years makes it very difficult for one to get matters in their true perspective to-day. Views are held in some quarters that automatic testing arrangements which dealt fully with Automatic Switching equipment must be fearful and wonderful as well as "expensive." Men who supported unstintingly the introduction of automatic switching long before such views were popular consider that automatic testing must mean also a manual "Tester to test the Tester," and rule the matter as being outside the realm of practical politics. It is therefore necessary to deal with this conception before furnishing any actual circuit details relating to suggested Automatic Routine testing schemes.

However natural such views may appear on the surface, careful examination of the problem reveals that, instead of employing for this important work uncanny automatic schemes necessitating frequent overhaul by highly skilled manual staffs, the functions which automatic testers have to fulfil may be simpler and more clean-cut in character than those required of automatic switching equipment. In order to gain this end each complete test may be split up into a cycle of single simple operations, each tester operation being associated with a definite function of the automatic switching plant under test. A pointer moving over a circular scale as each function is tested can serve to denote any particular function which, through failure, causes automatic stoppage of the testing cycle. A glance at the case of the Final Selectors (or Connectors) of the ordinary P.B.X. type will be helpful in this connexion. Under the influence of the last 2 digits dialled the wipers of these switches move in the Vertical and Rotary planes, and, when necessary, continue to hunt automatically beyond the last number dialled in search of the first disengaged line of a group. Seizing of a wanted line leads to that line being ' engaged " against intrusion by other callers, and also to the transmission of ringing, speaking and metering currents, etc. The satisfactory operation of the relays, magnets, wipers and mechanical switch contacts, etc., which function (on each single switch) to reach and search over groups of lines, can be confirmed by employing the Generator currents (transmitted to the only disengaged line of a " test " group) to advance an automatic testing cycle a single step.

The practicability of establishing interdependence between the complete and satisfactory functioning of the tester and the plant tested can also be demonstrated by reference to the alternative case of a simple jack-ended junction circuit. In this instance commencement of the cycle of tests would occur only with the forward movement of a tester relay, which draws its operating current through the answering lamp of the junction under test. The next step in continuance of the cycle of tests occurs only when releasing of this relay follows earthing of the answering lamp circuit by the junction line relay. (The first forward movement of the tester relay is employed to close a circuit which originates a call on the junction equipment.) To summarise the foregoing. *Each tester will proceed automatically from the first junction (or automatic switch) to the second, when, and only when, the first junction has been tested and proved satisfactory. Therefore, whenever the machine stops before all tests have been completed, the stoppage is due to the existence of a fault. An investigation must be made into* *the cause of the fault and the machine restarted. It is true that the fault in question may be located in the testing machine, but there is no need to apply a "parasitic" routine test of the Automatic Routine tester in order to determine this.*

The folowing affords an idea of the relative numbers of moving contacts involved :—

P.B.X. type Final Selector			40
Manual type Tester for	do.		25
Semi-Auto.	do.	do.	22

The object of the present article is to deal in broad outline only with principles thought to be capable of useful development and application. For this purpose it is proposed to describe :—

(*a*) A set for making full automatic tests of junction circuits.

(*b*) A semi-automatic set for final selectors.

(*c*) i. An automatic circuit-selecting scheme suitable for hunting over large groups and connecting junctions or switches to sets similar to those referred to under (*a*) and (*b*).

ii. A means of adapting the circuit-selecting scheme for enabling automatic traffic-recording facilities to be applied.

The Traffic-Recording scheme to be dealt with under (*c*) ii. is based upon principles first evolved some years ago by Mr. G. F. O'dell. The employment for routine testing purposes of a switching scheme covering large groups of switches would lend itself to the employment of a Traffic-Recording scheme of this particular character.

TESTS OF AUTO TO MANUAL JUNCTION CIRCUITS.

(i.e., *of simple line and associated direct signalling equipment*).

The routine operations performed daily in completely testing trunk and junction circuits connecting manual exchanges are familiar to all. At large automatic exchanges a considerable number of junctions connect the Automatic Switches to the manual portions of the exchange, and it is the practice for each of these circuits to be tested daily.

In planning to test each function which the junction equipment performs, the scheme followed has been to endeavour to set up electrically each changing condition as is it established by the connecting of the calling subscriber's loop across the junction and by the insertion of an answering plug, etc. The arrangement to be described is shown in Fig. **1**. The junctions are led to the bank contacts of a preselector which has the testing equipment associated with its wipers. The junction shown in Fig. **1** is a typical circuit. The functions which will be tested are :—

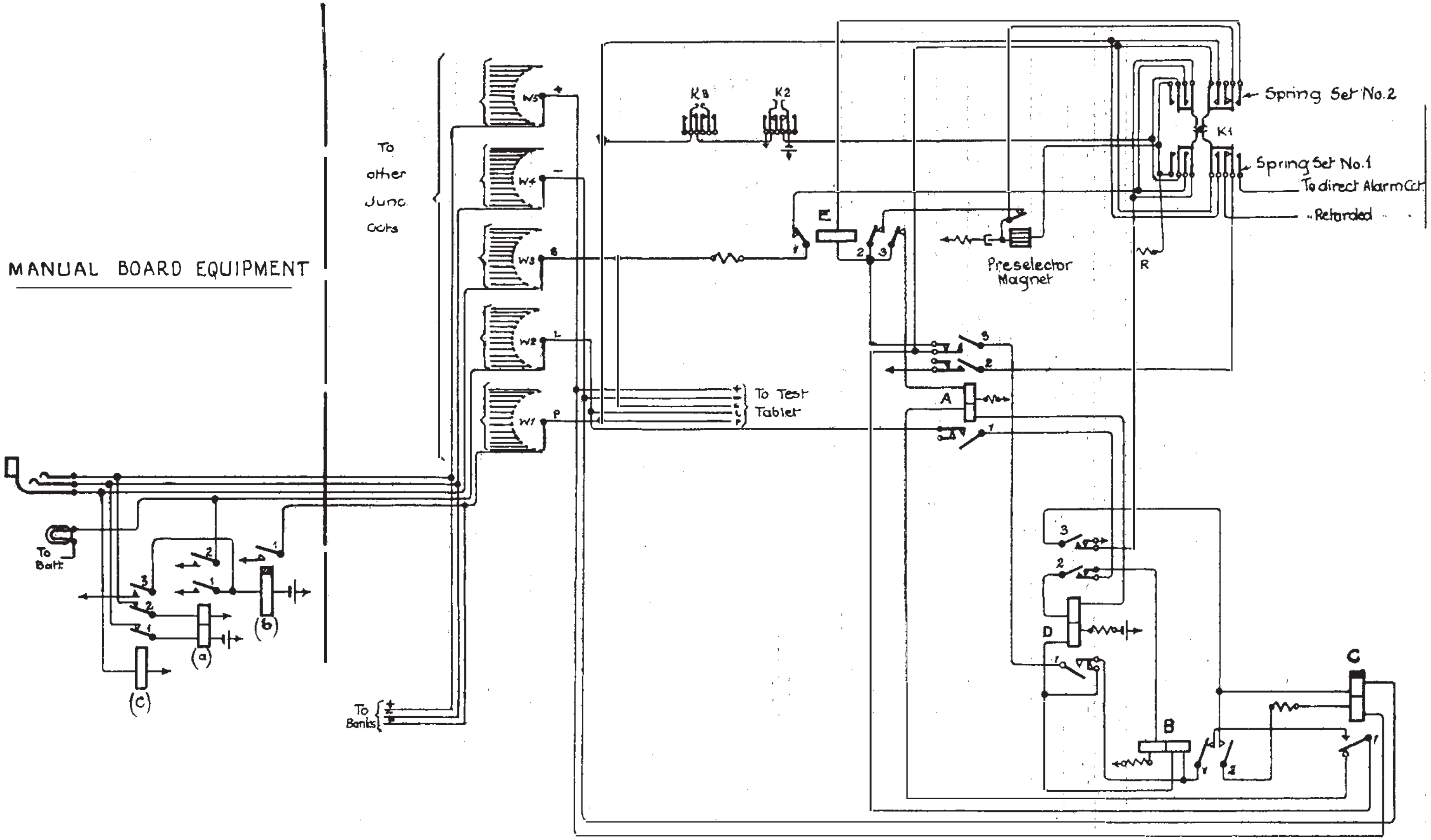


Fig. 1.—Auto to Manual Junction Circuits.
Relay equipment, etc., for routine testing when Circuits are wholly internal.

1. Continuity of line lamp circuit.
2. Operation of the line relay on Sub.'s loops of maximum resistance.
3. "Holding" of the calling subscriber's line, *i.e.,* earth connecting of the "engaged test" or "P" wire.
4. Control of the cut-off relay on the junction equipment.
5. Insulation of the junction circuit.

The lever of key K1 is operated to control spring set No. 1, when battery is connected through the Preselector Magnet and its interrupter to the wiper which connects up the "P" or "test" wires of the different junctions. The preselector rotates until an idle junction is reached, when a cycle of operations as under takes place. Before proceeding to deal with the actual junction testing circuits it will be well to trace the path of the preselector magnet when "engaged" junctions are tested. Under these circumstances current flows from battery K2, K1, magnet coil and interrupter contacts, E2, A3, K1, Wiper No. 1 and the junction circuit, to earth at the operated contact of relay (*b*) of the auxiliary equipment.

The following circuits are set up as each junction is seized:—

i. Relay A operates due to the current connected to the preselector magnet and its interrupter, flowing *via* E2 and E3 to earth through the upper coil of A.

ii. Current from the answering lamp circuit then flows *via* Wiper No. 2 and relay contacts A1, D2, to the left hand coil of relay B, which operates. Satisfactory continuity of the answering lamp circuit (see function No. 1 above) is thereby proved.

iii. Closing of the No. 2 contacts of B connects the coils of relay C across the junction loop *via* Wipers 4 and 5, when the flow of current through the coils of the junction relay (*a*) cause that relay and also relay C to operate. The operation of (*a*)2, earth-connects the answering lamp circuit direct, thereby short-circuiting the operating coil of relay B which releases in consequence. Release of B confirms satisfactory closing of the (*a*)2 relay contacts—see function No. 2. The operation of relay contact (*a*)1 completes the path of relay (*b*), which in turn earth connects the "engaged test" or "P" circuit.

iv. Relay C is slow-releasing and completes a path immediately B falls back for the operation of D. The path for the operation of D is completed *via* its lower winding and the contacts normally closed on its own No. 1 spring set, *via* B1, C1, K1 and Wiper No. 1 to earth at the operated No. 1 contact of relay (*b*). Satisfactory "holding" of the calling "line" (see function 3) is thereby confirmed.

v. The operation of contacts D1 causes its retaining current to circulate through the right hand winding of B. This latter relay operates a second time to loop the two coils of C which bridge the junction circuit. The retaining current of D and B flows *via* D1 and A3, etc.

vi. The operation of D3 removes an earth connection, short circuiting the cut-off relay circuit, when there is a flow of current *via* K2, K1, R, the second springs of K1 and E1 to the No. 3 wiper and thence *via* the junction circuit to the cut-off relay (*c*)—see function 4. The operation of the cut-off relay opens the circuit of relay C on the testing equipment.

vii. A path is also provided for the current connected to R to pass *via* D3 to both wires of the junction loop (contacts B2 are closed). Should any earth or battery fault exist on the junction a current will flow through the winding of the slow releasing relay C and so hold up that relay—see function 5.

viii. When the junction circuit is clear relay C releases shortly after the cut-off relay (*c*) operates, when a path is completed for the answering lamp circuit *via* Wiper 2, A1, D2, upper coil of D, lower coil of A, C1, etc., to earth at the contacts of relay (*b*). The flow of this current through the separate coils of relays D and A neutralises the earlier magnetisation of these two relays. Both relays release in consequence.

ix. The release of D causes (*c*) to release, relay (*b*) then releasing with a retarded action due to its copper slug. The restoration to normal of contacts A3 extended the preselector magnet circuit to the earth connection existing on (*b*)1 when the preselector steps forward to select another trunk.

The cycle of operations just described takes about half a second to complete. Should the presence of a fault on a junction prevent release of relay A, the circuit through the contacts A2 completes the circuit of an audible alarm.

In order to afford ready access to a circuit whenever premature stoppage of the testing cycle indicates the existence of a fault the five wipers of the stepping preselector are connected to the Test Panel, and a locking type Key (K2) is provided to enable Auto testing to be suspended whilst the faulty junction is taken in hand. The third non-locking type Key (K3) enables the guarding earth to be removed from the faulty junction during the fault localisation tests.

It will be seen that the number of junctions which can be tested is limited by the number of positions on the preselector arc. Details will be furnished later of arrangements whereby completion of the tests of a group of circuits can be made to lead automatically to the switching over of another set of circuits to the bank contacts of the test-set preselector.

As already indicated the equipment described will test junctions at the rate of 120 per minute, so that even for the largest exchanges the time taken in an early morning test of all disengaged junctions would be almost negligible.

The operation of key set springs No. 2 so alters the connections of the equipment as to test each junction in turn, instead of skipping over each circuit found to be engaged. Upon the wipers reaching an engaged junction, relay E operates and so delays the commencement of the normal testing cycle. The normal release of the junction causes E to release when the testing cycle is recommenced. The scheme provides therefore for a quick early morning test of all disengaged junctions, to be followed by a test of each junction taken in turn.

The arrangements described would, of course, require amplifying for cases where the automatic switch banks and the Manual Board equipment are accommodated in separate buildings.

This scheme does not provide for the employment of a pointer for indicating each switch function under test.

SEMI-AUTOMATIC TESTER.

Fig. **2** furnishes the circuit arrangements, etc., of a Semi-Automatic Tester suitable for use on Final Selectors. These switches have subscribers' lines connected to the bank contacts, and, in addition to selecting the wanted line under the control of the caller's dial, feed Ringing, Busy back, and Transmission currents, etc., as occasion requires.

Flexible cords are employed to connect up the tester to each switch, and to the test line (usually 99) appearing in the subscribers' multiple.

Tests of a purely manual character, have called hitherto for the manipulation of each appropriate test key in turn in order to " switch " the conditions required for each test. In the semi-automatic set the switchings are performed by the employment of moving preselector wipers and four relays. The moving wipers are made to " step " only in response to the satisfactory functioning of the automatic switch. The ideal arrangement would, of course, be one in which the auto switch functions were allocated individual positions in the stepping cycle, thus leading to any failure of the switch to " step " being definitely associated with a single switch function. The chart which accompanies the

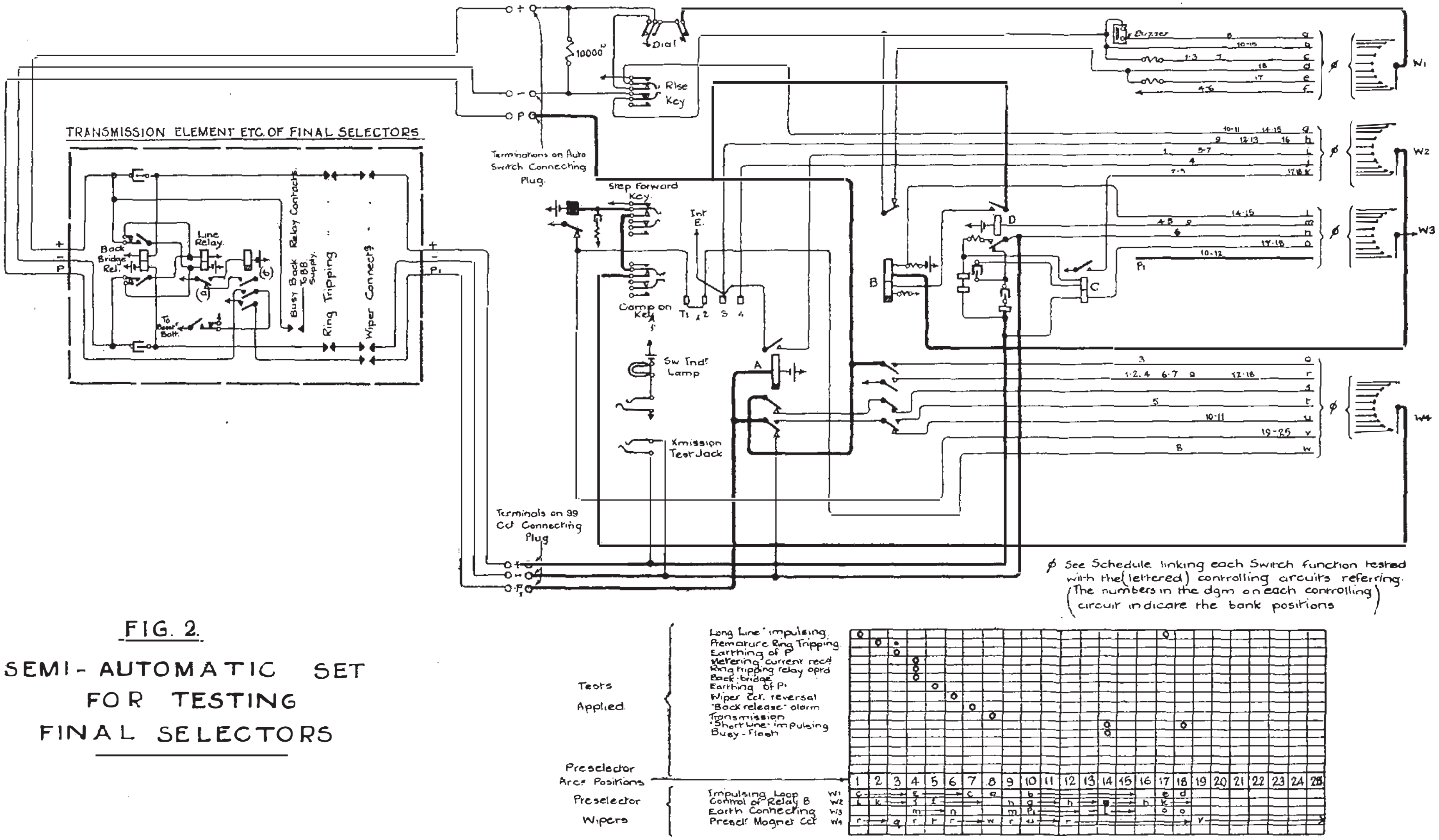


FIG. 2.

SEMI-AUTOMATIC SET FOR TESTING FINAL SELECTORS diagram links the switch functions with the relevant positions of the stepping preselector. The moving wipers switch four different circuits as desired, and it will be necessary to trace each of the four control circuits relating to any particular position of the stepping switch in order to understand the tests relating to the switch function concerned. The lower part of the schedule links the circuit controls with each switch position.

In reviewing the arrangements shown it is preferable to consider the whole as being built up of a number of self-contained units or functions. Each position of the arc and the control circuits which operate should be considered apart from the remaining arc positions.

Commencement of the testing cycle follows the dialling of 99 by the switchman, the dialling circuit being *via* Wiper No. 1, and circuit (*c*). The wipers of the Final Selector are raised to the 9th level and come to rest upon completion of the 9th rotary step. The following notes deal with the control of the preselector magnet, and consequently direct attention to the testing conditions linked with the different switch functions upon which stepping of the test set depends.

1. *Stepping from Position No.* 1. (Proving satisfactory impulsing on " long line " circuits).

The magnet circuit (with battery behind it) which is connected to Wiper No. 4 and circuit (*r*) depends upon the movements of relay B. This relay is *via* (*i*) and operates from the intermittent earth circuit, only after relay A has operated. Relay A (which is comparable with a subscriber's cut-off relay) is connected to the bank contacts of the line which corresponds with the number dialled, hence the operation of A confirms satisfactory impulsing.

2. *Stepping from Position No.* 2. (Confirming " No premature ring-tripping ").

The magnet circuit is again connected to circuit (*r*). Relay B now receives its circuit *via* (*k*), which is earth-connected with the forward movement of relay C. This latter relay forms part of a " ring-receiving circuit " bridged across the 99 line and responds to generator currents. (The further movement of the preselector magnet from position 3 to 4 is also dependent upon the continuance of the machine-ringing signal through C). The ring-receiving circuit through C, etc., applies a severe test of the liability of the auto switch relay to trip prematurely.

3. *Stepping from Position No.* 3. (Confirming that a full earth connection has been applied to P).

As indicated in (2) relay B still operates *via* the contacts of C to control the magnet circuit, an alternative contact of B is employed however, circuit (*q*) serving to connect the magnet to the P circuit.

4. *Stepping from Position No.* 4.

(*a*) Receipt of " Booster " metering current.
(*b*) Operation of " Ring-tripping " and " Back-bridge " relays.

(*a*) The magnet circuit *via* (*r*) is connected to full earth at the operated contacts of relay B. The normal winding of B is left disconnected. The second earth-connected winding of B has a path provided from it to the release trunk circuit P *via* the operated contacts of relay D. A momentary positive battery (known as a " Booster Metering current ") is applied to the release trunk after the called subscriber has answered, and to this current B responds.

Relay D, referred to above, is operated *via* (*m*) and serves the double purpose of completing a path for the metering current and also connects up a ring-tripping circuit across the 99 line.

(*b*) Application of a ring-tripping loop not only operates the ring-tripping relay, but also the back-bridge relay which reverses the battery and earth connections to the incoming trunk. Immediately ring-tripping conditions are applied therefore, the holding loop on the incoming trunk (*via* Wiper No. 1) is replaced by a single earth connection applied to the positive line. A current reversal is therefore necessary for the switch to " hold " by virtue of the flow of current through the line relay. Under normal circumstances the ring-tripping and back-bridge relays operate in quick succession to establish the reversal conditions referred to above. Any slugginess in the operation of either these two relays delays the time when a " holding " current flows and causes premature release of the switch. Release of the switch intercepts the automatic stepping of the tester.

At exchanges where " booster battery " metering is not provided a strap is placed between the terminals T3 and T4 in order to provide for the operation of relay B from the intermittent-earth circuit.

5. *Stepping from Position No.* 5. (Confirmation of " holding " earth on P_1).

The magnet circuit receives its earth from the P_1 conductor *via* circuit (*t*), which is closed finally with the movement of relay B. This relay operates on the intermittent earth *via* circuit (*i*) and the operated contacts of relay A.

6. *Stepping from Position No.* 6. (Test for reversal of wipers).

The magnet circuit is controlled *via* (*r*) from the contact of B which connects up earth direct. Relay B depends upon the retention of A for its intermittent-earth connection. Holding of the auto switch (for the retention of A) is by means of an earth connection on the positive trunk only, the " current reversal " condition being arranged for by an earth connection (*via* circuit (*n*)) on the wiper circuit, which should connect up the negative coil of the back-bridge relay.

7. *Stepping from Position No.* 7. ("Back release" alarm signal).

This is the first position in which auto stepping is independent of the existence of a fault. The magnet control is *via* the " direct earth " circuit of B. Relay B operates *via* the intermittent earth circuit. During the time the wipers stand on Position No. 7 (1.5 second) a supervisory signal on the switch glows, indicating that although the switch is still " held " on the calling side the called subscriber has cleared and his line is being " held " after completion of a call.

8. *Stepping from Position No.* 8. (Transmission tests).

Normally the preselector magnet circuit is closed *via* its own interrupter and circuit (*w*) in order to skip quickly over this position, since the normal routines do not test the continuity of the condensers employed in the transmission circuit. Removal of the strap between terminals T_1 and T_2 leaves the preselector magnet disconnected in position 8 in order that transmission tests may be made. The incoming trunk is connected across a buzzer *via* circuit (*a*) in this position, and satisfactory transmission conditions can be confirmed by connecting a switchman's hand telephone to the " transmission test " jack (bridged across the 99 line) when a characteristic " buzz " is heard. The switch has to be stepped forward manually by means of the " step forward " key in completion of the tests.

Occasional tests for transmission would be made by means of the " step forward " and " camp on " key controls.

9. *Stepping from Position No.* 9.

Automatic releasing of the switch occurs in position 9 preparatory to commencement of a test call to an " engaged " number in position 10. Normally a disconnection of the incoming trunk circuit on Wiper No. 1 causes release. Arrangements are made on Wiper No. 3, however, to operate relay D and the back-bridge relay, in order to bring to light during ordinary routines any failure of the back-bridge relay to operate quite definitely. It will be seen that the trunk-circuit reversal is effected by the employment of make-before-break springs on the back-bridge relay. Any failure of an inner spring to " break " short-circuits the caller's line and would prevent automatic release of the switch in this position.

The preselector magnet is connected to the earth-connecting spring of relay B, which operates in turn under intermittent-earth control.

10. *Call to an " engaged " number.*

As in the earlier test relating to a completely effective call automatic stepping of the test set preselector occurs only with the manipulation by hand of the test set dial. The earth-connected Wiper No. 3 is employed to "engage" the 99 Test line, and it has been found desirable to economise in the number of relays required by employing a scheme which results in a single automatic step of the preselector each time a digit is dialled. Upon completion of dialling, therefore, the preselector stands in position No. 12. Stepping of the switch to positions 13 and 14 is under the direct control of relay B, which operates *via* the intermittent-earth circuit, the test for " busy back " being applied in positions 14 and 15. The single wire Exchange busy-back circuit which supplies battery and earth alternately is applied to the positive wire of the ingoing trunk on " engaged " calls, and relay B is connected to this wire *via* circuit (*g*) in positions 14 and 15 of the arc. Relay B, which closes the magnet circuit direct, has the opposite side of its winding (which normally has battery connected through a resistance) earth connected *via* circuit (*l*) by Wiper III. This relay therefore " flashes " in the same manner as does an ordinary cord circuit supervisory relay on connection to a busy-back circuit, and the switch wipers step to position No. 16 when automatic releasing occurs due to the incoming trunk loop being disconnected at the bank circuit of Wiper No. 1. The preselector steps forward to position No. 17 under the control of relay B (this relay is connected to the intermittent-earth circuit). It will be noticed that impulsing for this test is *via* a " short line " circuit (on Wiper No. 1), and the completion of a satisfactory test may be taken as an indication that the switch will impulse satisfactorily when connected to lines of zero resistance.

11. *Simple tests for impulsing.*

Rapid tests for satisfactory impulsing can be made without the necessity for going through the whole cycle of operations involved in complete calls. Position No. 17 so connects the circuits that in response to satisfactory switch functioning when 99 is dialled automatic releasing occurs, the impulsing loop being re-connected ready for another test without the necessity for stepping. The circuits shown provide normally, however, for a step-forward movement to position 18 to accompany the automatic release of the switch. A similar cycle of operations takes place in response to 99 impulses from the dial when the switch is standing in position

18. The difference between tests made in positions 17 and 18 lies in the fact that in the latter "short line" impulsing conditions are applied, whilst in the former "long line" conditions obtain. The operation of the "camp on" key enables a series of "long" or "short" line impulsing tests to be applied when necessary. Releasing of the auto switch occurs when the 99 line is reached due to the impulsing loop through (*d*) and (*e*) being completed *via* the resting contacts of relay B which operates. As will be seen from the diagram, the operating circuit of B is *via* the contact of relay C, the latter being connected *via* circuit (*o*) to operate on the "ringing return" current which is applied through the Selector wiper to the + conductor of the 99 line after that line has been seized by the automatic switch.

The circuits set up in positions 17 and 18 enable the set to be employed also for impulsing tests on group selectors, but under these circumstances releasing of the auto switch after each test has to be effected by manipulation of the "Release" key shown.

The preselector steps forward to the Number 1 position *via* its own interrupter circuit from position 19.

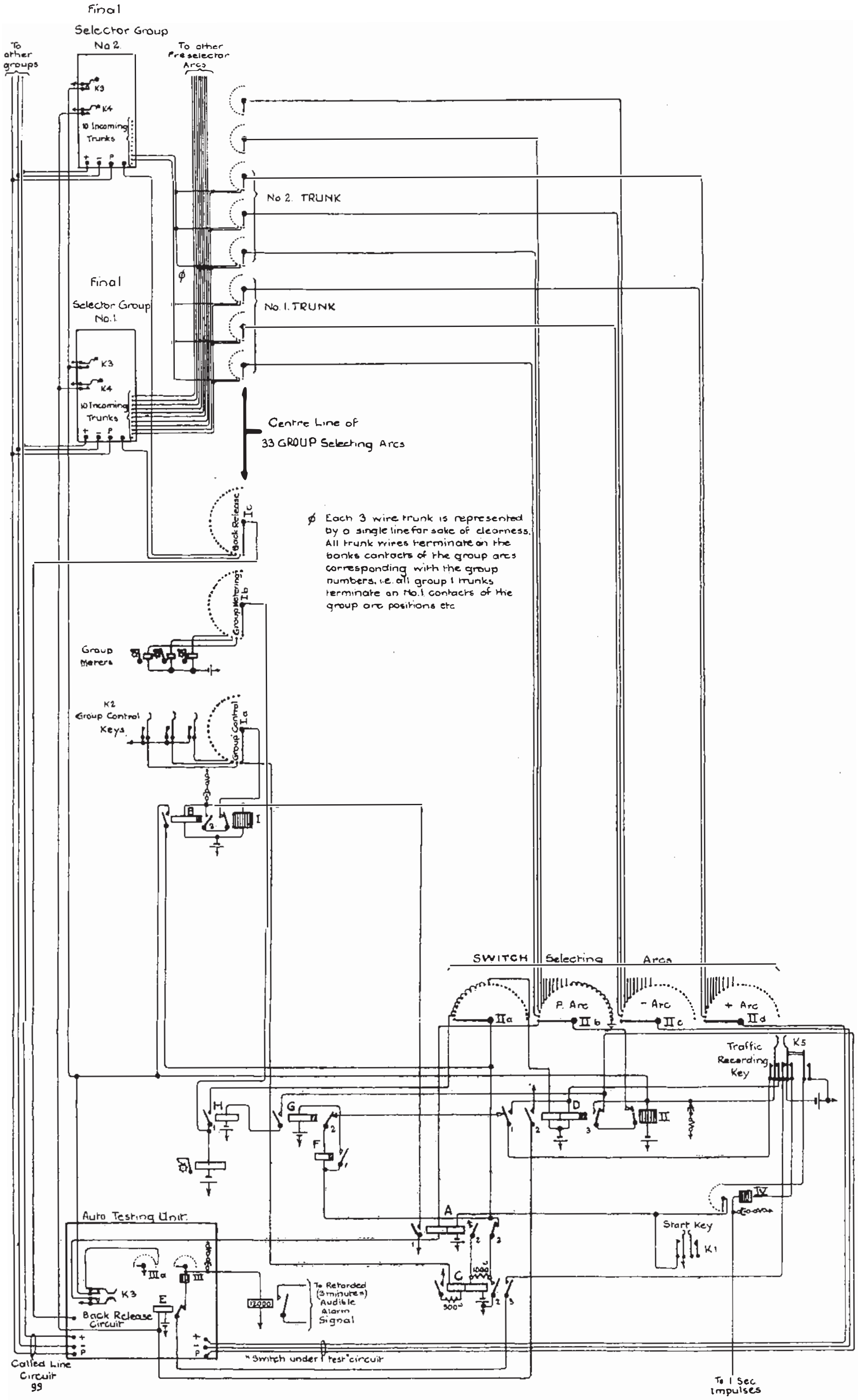
GROUP AND SWITCH SELECTING, ETC.

General Notes.

In furnishing the following outline of a completely automatic scheme, it should be stated that the testing methods advocated are based merely on the experiences afforded by working trials of a semi-auto set. On the other hand, however, the non-automatic features of the set already described are confined to the manipulation of a dial for impulsing purposes and to the connecting-up of each switch by hand.

The employment of automatic routine testing methods would make it necessary to consider the provision of a switching scheme with which to connect the testing set to each switch in turn. There are very many auto switches employed in even the smaller exchanges and, since each switch is controlled over a 3-wire trunk, the arrangements for switching to individual circuits call for the employment of wipers and banks capable of dealing with large groups of wires.

The arrangement shown in Fig. 3 is based on the employment of preselector type switches. It will be assumed for the purpose of this article that there is available a preselector employing a single stepping magnet circuit and having 33 wipers which sweep over as many bank arcs. The wipers afford simultaneous connection to groups of 33-wire circuits, and, allowing for a "home" position, the standard 25-point arcs cater for the connecting up of 24 separate 33-wire groups. 30 wires of each group are employed



ϕ Each 3 wire trunk is represented by a single line for sake of clearness. All trunk wires terminate on the banks contacts of the group arcs corresponding with the group numbers, i.e. all group 1 trunks terminate on No. 1 contacts of the group arc positions etc

FIG. 3.—ROUTINE TESTING AND TRAFFIC RECORDING.
Group and Switch Selecting Circuits, showing also equipment used for Trunk testing and Traffic recording.

to connect ten 3-wire trunks of a Final Selector group, the remaining three wires serving for "group control," "group metering," and connecting up the "Back-Release" Alarm circuit. It will be seen from the diagram that the 30 wires corresponding to 10 sets of trunks are accommodated on three of the four arcs of a standard 25-point preselector.

Before proceeding further it is necessary to indicate that upon completion of each individual switch testing cycle a short duration earth connection is sent out in order to provide for automatic switching of the test set to the next disengaged switch—See connection of Arc No. III. (*a*).

For Routine Testing Purposes.—For the purpose of ordinary routines each group of switches would be selected in turn, *i.e.*, circumstances would not call normally for any of the groups being omitted. With regard to the matter of individual switch selection it will be most convenient here to deal only with the simple case where the "Switch Selecting" wipers pass over the trunks of switches which happen to be engaged at the time of testing.

The cycle of operations commences with the momentary operation of the start key K1, which, during operation, energises relay A.

The momentary closing of contacts A1 completes the circuit of B and the preselector magnet No. I, when the group wipers move from the "home" position to the first group.

Simultaneous with the above operation the A2 contacts close the circuit of C, which operates and obtains a retaining circuit through its own C2 contacts.

The release of A precedes by a fraction of a second the release of B when a path is provided for D and the preselector magnet No. II. *via* C2, A3 and B1. The release of B opens this last mentioned circuit, when the switch-selecting wipers move forward and select the first disengaged switch in the group now connected to the bank contacts. The "testing" circuit of preselector No. II. is *via* D3 operated and its own interrupter to the "P" wiper on Arc No. II.*b*. The earth-connection which exists on the P circuits of "engaged" switches complete the preselector magnet circuit, the magnet interrupter giving rise to an automatic step forward movement until an "open" P circuit is reached.

The initial movement of contact C3 connected battery *via* the normal springs of the Traffic Recording key to the coil circuit of the preselector employed in the Tester. It will be seen, however, that this battery is again disconnected by the operation of relay E which occurs *via* contacts D2. Forward movements of the Test set preselector during group and switch-selecting is thereby prevented.

As already indicated the short-duration earth which is transmitted from the III.*a* arc upon completion of each switch-testing cycle gives an additional impulse to the Switch-Selecting preselector. When the wipers of this latter switch reach contact No. 12 (contact No. 11 connected up the 10th switch) the preselector moves quickly forward to its " home " position due to all the bank contacts tested being found " engaged." Immediately the home position is reached current flows momentarily *via* the II.*b* arc to the earth connected coil of A, which operates until contacts D3 of the slow releasing relay restore. Relay D fails to retain through the high resistance circuit of A due to the fact that its coil is shunted by the 75$^\omega$ winding of the preselector.

The second movement of A1 transmits another impulse to the group-selecting switch which switches in the next group, and provides also another " starting " impulse for the switch selecting arcs by completing a momentary path *via* C2, A3 and B1.

Upon completion of tests over all available routes the testing cycle is brought to a conclusion by the group-selecting wipers reaching the home position. In this position a circuit is competed for the preselector magnet current to flow through the B2 contacts and the wiper of the I.*a* arc to the second coil of relay C. This current reverses the magnetic flux of relay C, which releases in consequence. The release of C leaves its two windings disconnected and cuts the circuit of the battery supply to the routine tester.

Special Case.—In the event of a switchman wishing to examine critically the performances of some particular switch under routine testing controls, arrangements would be made to suspend the automatic step-forward control after this switch has been selected, by operating key K3 on the tester. The operation of any one of the K4 keys fitted on the selector units energises E, disconnecting the circuit of the stepping magnet and so enabling the switchman to " camp on " any desired position of the testing preselector arc. Thus " long line impulsing " conditions could be applied continuously if desired, or alternatively the preselector can be brought to rest in an appropriate position should it be desired to make relay readjustments on the automatic switch.

Before leaving the matter of routine testing of Final Selectors it should be stated that for the sake of clearness the arrangements described assume that the number 99 circuit of each 100 line block may be reserved for routine testing work. Arrangements are being made to obviate the necessity for reserving these lines, but a description of these arrangements would not contribute to the main purpose of this article.

Traffic Recording.—The Traffic Recording facilities cater for the registration of the number of times switches are found to be engaged when they are tested at regular intervals. The testing cycles are timed to occur every 36 seconds, *i.e.*, every .01 hour. With the scheme shown only one switch is tested at a time so that the total number of switches tested within the 36-second period will depend upon the length of time required for each test and successive switching. The arrangements shown will not test more than ten groups of ten switches each within a period of 36 seconds.

All "group control" keys require to be operated excepting those corresponding to the units on which it is desired to take records. When this has been done the Traffic Recording Key K5 is operated. This operation connects up the preselector magnet No. IV., when a complete cycle is made every 36 seconds. Each complete cycle causes a one second impulse to be transmitted to relay A.

The following operations then occur :—

The momentary closing of contacts A1 energises B and the preselector magnet I. when selection of the first group on which Traffic Records are to be taken commences. The group testing circuit is *via* contacts B2 and the group Arc I.*a*.

The closing of contacts B1 during group selection completes a path for preselector magnet II. *via* A3 and C2. Immediately the B1 contacts open, the current through the preselector magnet II. finds an alternative path through K5, D1 (normal), G2, relay F, A3 and C2 to earth. The series relay F operates in consequence, providing a path for the operation of G *via* F1, A3 and C2. The resulting operation of G intercepts the flow of current through the series relay, etc. (at G2) and the preselector steps forward. As will be seen from the diagram, F and G are slow-releasing type relays and the circuit just described provides for a series of single pulses to be transmitted to the switch-selecting wipers.

Each switch trunk is tested for traffic recording purposes by its connection to relay H immediately the switch-selecting wipers move forward to it and before relay G has had time to release. The testing circuit is *via* G1, D3, the magnet interrupter and arc No. II.*b*. The operation of H when an engaged circuit is tested records a call on the common meter (*via* H1, II.*a*, A3 and C2) and also on the group meter concerned (*via* arc I.*b*).

Immediately the switch-selecting wipers reach position number 12, further registrations are prevented by the disconnection of the local circuit of H, whilst an earth connection is applied *via* the II.*a* arc to the second coil of relay D. Immediately the forward movement of D closes its D1 contacts the first coil is once again connected in parallel with the preselector magnet and the two are connected *via* D3 and the interrupter to the earth-connected section of the II.*b* arc. Automatic rotation of the switch-selecting wipers now steps this switch to the home position.

Relay A then receives another short duration impulse (*via* D3 operated, the magnet interrupter and the home position of the II.*b* arc) and thereby sets in motion the Group-Selecting Wipers *via* the A1 contact. The next available group is then selected in the manner already indicated, the release of relay B leading up to the single-step movements of the switch-selecting arcs being recommenced *via* the F series relay circuit, in the manner already described.

As the Group-Selecting wipers move from Group to Group the appropriate group meters are switched in *via* the I.*b* arc.

When the I.*a* wiper reaches the home position upon completion of tests over all available routes, automatic release of C occurs in the manner already indicated in connection with the scheme for routine testing, *i.e.*, *via* the I.*a* wiper and the second or polarity-reversing winding of relay C.

Recommencement of the full traffic-recording cycle occurs with the closing of the circuit of relay A *via* the wiper circuit of preselector No. IV. every 36 seconds.

It should perhaps be stated for the benefit of those readers who have not actually handled preselectors (or rotary line switches) that the foregoing notes have been based on the employment of the type of switch on which the wipers step forward only on the interruption of the flow of current through the magnet coil. In some of the earlier preselectors the wipers were "Magnet driven" as distinct from "spring driven."

The use of a semi-automatic testing set reduces the manhours spent by 40 per cent., and, whilst simpler to manipulate than the purely Manual Tester, applies more searching as well as more uniform testing conditions. Full automatic testing would practically wipe out all labour charges on routine work.

A few further remarks on the assistance which the employment of mechanical aids may afford the exchange staffs, may not be out of place. Under the manual conditions of testing a not inconsiderable proportion of the switchman's time, and some mental effort, is expended in handling and connecting up the portable testers, the manipulation of dials and keys, and in the observation of lamp and bell signals, etc. Transference of the work to a suitable machine would enable the switchman to devote his skilled attention more carefully to relay adjustments and other important work, and also provide him with rapid "fault indicating" sets for the units which perform functions so numerous and varied.

The Automatic Testers lend themselves readily to the inclusion of tests covering the behaviour of a greater number of individual relays on each unit tested than would be practicable with the retention of methods which are wholly manual. They also render practicable the application of both "safe working" and "re-adjustment" standards. The latter standard would, of course, be employed whenever failure of a switch to pass the normal "safe working" conditions rendered readjustments necessary. It is thought that these facilities would be especially advantageous in assisting towards the maintenance of greater uniformity with regard to the adjustments applied by the different exchange staffs. The very considerable increase in the quantity and type of relays employed in Automatic working make the matter of uniform and efficient relay adjustments one of outstanding importance and extensive investigations have been conducted in this connection. This phase is of course inseparably linked up with the matter of fault detection. The length of the present article precludes, however, any more complete reference to this aspect of maintenance work.

LETTERING OF RELAYS IN AUTOMATIC TELEPHONE DIAGRAMS.

ABOUT fourteen years ago the first article on Automatic Circuits appeared in this Journal, and since that time the problems incidental to the general introduction of automatic working have been examined with increasing detail.

A minor problem, which was yet sufficiently important to require special treatment, was that of Relay Lettering in Automatic Circuit Diagrams. Until quite recently the lettering of relays was based either upon no particular plan, or upon the positions of the relays on their mounting plate.

In the latter case, modifications in circuit design necessitating an addition to or reduction in the number of relays entailed an alteration in the lettering, with consequent rewriting of all circuit descriptions.

A change of letter also had the serious drawback that a letter which had become familiar to the staff as belonging to a certain function, *e.g.*, F = ringing trip relay, might at any moment be allotted to a relay having an entirely different function to perform. With the increasing use of automatic circuit diagrams, a scheme of standard lettering became essential and the following list was devised. This will be used by all P.O. Contractors in future. It will be noticed that the letters A-M have been reserved for the relays most commonly met with. Double letters are used for the remaining cases. The letters allotted to Switch Mechanisms, etc., are primarily for use on wiring diagrams where every terminal must be clearly indicated.

SCHEDULE OF NOMENCLATURE FOR AUTOMATIC TELEPHONE EQUIPMENT DIAGRAMS.

SINGLE LETTERS.

RELAYS.

A	Impulse Accepting Relay.
B	Guard Relay.
C	Vertical movement Relay (series or shunt).
D	Forward or Called Party's Supervisory Relay.
E	Rotary movement Relay (series or shunt).
F	Ringing Trip Relay.
G	Busy or Test Relay.
H	Wiper Cut-in Relay—Selectors.
I	Retardation Coil or Relay of High Impedance.
J	Booster Relay, Final Selectors Non-Director Areas.
K	Wiper Cut-in Relay, Rotary Switches.
L	Calling Party's Line or Supervisory Relay (Non-Impulsing).
M	Forced Release Relay.

SWITCH MECHANISMS.

N	Vertical Off Normal Springs (For Rotary Off Normal Springs see NR).
P	Private.
Q	
R	Rotary Magnet (not breaking its own circuit).
S	Cam Springs.
T	Test Jack.
U	Switch Jack
V	Vertical Magnet.
W	Wiper.
X	(Reserved for Relay Spring Adustment Conditions).
Y	
Z	Release Magnet.

DOUBLE LETTERS.

CC	Counting (Impulse) Control Relay (Director).	
CO	Cut Off Relay (Director).	
DD	Digit Distributor Switch.	
DM	Driving Magnet (breaking its own circuit) Rotary Switches.	
DS	Digit Distributor Stepping Relay (Director).	
GA	First additional Test Relay	11-20 P.B.X. Final Selectors
GB	Second ,, ,, ,,	
HS	Hunting Start Relay (2-10 P.B.X. Final Selectors).	
LC	Line (Impulse) Control Relay (Director).	
MB	Manual Board Relay (Director).	
NP	Normal Post Springs.	
NR	Rotary Off Normal Springs.	
PA	Pulse Alarm (Director).	
QA	Condensers.	
QB		
QC		
QD		
etc.		
RT	Routine Test Relay (Director).	
RA	Release Alarm Relay ,,	
SA	Start Send Relay (Director).	
SC	Sender Control Switch ,,	
SS	Sender Switch ,,	
SZ	Stop Send Relay ,,	
TP	Time Pulse Relay (Director).	
YA	Resistances.	
YB		
YC		
YD		
etc.		

TESTING-OUT AUTOMATIC EXCHANGES.

By W. PRICKETT,
Engineer-in-Chief's Office.

THE testing-out of automatic exchanges will be a subject that the Department's engineers will be concerned in very much in the future, and it was thought that a short article on this subject would not be out of place.

At an informal meeting of the I.P.O.E.E. held recently in London, Mr. Judd, of the South Internal Section, gave a very interesting paper on " The Duties of a Clerk of Works." In the course of his remarks he stated that one of the chief duties of the Clerk of Works was to do " testing," " more testing " and " still more testing " ; he was referring, of course, to manual exchanges and if this be true, as we know it is, of manual exchanges, how much more so does it apply to automatic exchanges, where apparatus is doing work previously done by operators.

The following tests have been designed principally for automatic exchanges of the A.T.M. Coy's type in the provinces. London, with its Director and Tandem exchanges, will require dealing with specially. The tests given are not necessarily in the order in which they will be done.

Relays, etc.—These are tested for resistance by a Bridge Megger in the usual manner. In exchanges over 1,000 lines at least 5% of the relays and magnets must be tested; in exchanges under 1,000 10% must be tested. The coils are considered satisfactory only if the resistance be within 5% of that specified.

Group Selectors.—These are tested for vertical and rotary motions.

Busy-Back and Continuity of Wipers and Banks.—A tester has been designed to use with the switches, which permit of these operations being verified.

Continuity Test.—The continuity of the cables, etc., is proved by means of buzzing on each wire.

Outgoing Trunks from Preselectors to 1st Group Selectors.—These trunks are being tested automatically. An experimental tester has been designed for the purpose and is being used on different installations. Each trunk on a subscriber's preselector is engaged in turn, so that every trunk is proved from the preselector. This tester will make 5,000 tests in one hour.

Meters.—Every subscriber's meter is tested 10 times with an operating and 10 times with a non-operating current through them. A tester has been designed which gives the necessary conditions and also makes the 10 contacts automatically one after the other. This test is in addition to the tests applied to the meters at the factory.

Insulation Resistance of Cables, etc.—All local wiring and cables are tested for insulation resistance, both before being connected to the banks, etc., and after. The test is made by taking four wires equally spaced in the outer layer of each cable, and testing (*a*) between one wire and the other three wires separately, (*b*) between the four wires connected together and earth.

Each subscriber's line is tested from the Main Frame towards the exchange, (*a*) between the A and B lines, (*b*) between the A and B lines connected together and earth.

After the cables have been connected to the banks and apparatus, each switch is tested from the test jack.

All local wiring is tested between each wire and earth.

Final Selectors.—A modified routine tester, No. 11A, is used for testing the final switches. The tester is used in conjunction with line No. 99 on the unit, this line being extended to a jack for the purpose. The switches are tested for vertical and rotary motion, ringing, premature tripping, No. 99 line engaged, etc., transmission and busy-back.

Test and Trunk-offering Distributors and Final Selectors.—These are tested from the Test Desk and Manual Board respectively. Each distributor is tested to a number reached by each final selector.

Outgoing Lines from " A " Boards to Automatic Equipment.—Each line is tested separately from the manual board. A telephone is connected to a certain number on the MF and this number is dialled on the line at the manual board.

" O " Level Circuits. Enquiry Lines.—All circuits are tested from the first switch on each shelf of 1st Group Selectors.

Phonogram Lines.—These are tested from the test jack of the repeaters associated with the phonogram lines.

Incoming Repeaters.—A tester has been designed to reproduce the manual conditions and the repeaters are all tested locally (*i.e.*, in the automatic exchange) so that all necessary adjustments can be made before being tested with the distant manual exchange.

Supervisory Signals and Alarms.—As the conditions in each exchange will vary, these circuits are tested out to see that they conform to the requirements as laid down in the specification for the particular exchange equipment under test.

Call Through Test.—This test is the final test to be made in the exchange and should not be carried out until the exchange is ready for working. All cross-connections should be run and the charts made out ready for checking. The complete series of tests are as follows :—

(*a*) One outgoing call shall be made and one incoming call shall be received on each subscriber's line at the Main Frame.

(*b*) An outgoing call shall be made from the first subscriber's line in each group as follows :—
  (1) To every final switch in the exchange.
  (2) To the Manual Board *via* the " 0 " level circuits.

(*c*) A call shall be made from the outgoing end of each junction as follows :—
  (1) On all junctions to the other automatic exchanges in the multi-office area.
  (2) On all junctions to manual exchanges.
  (3) On all junctions from manual exchanges.

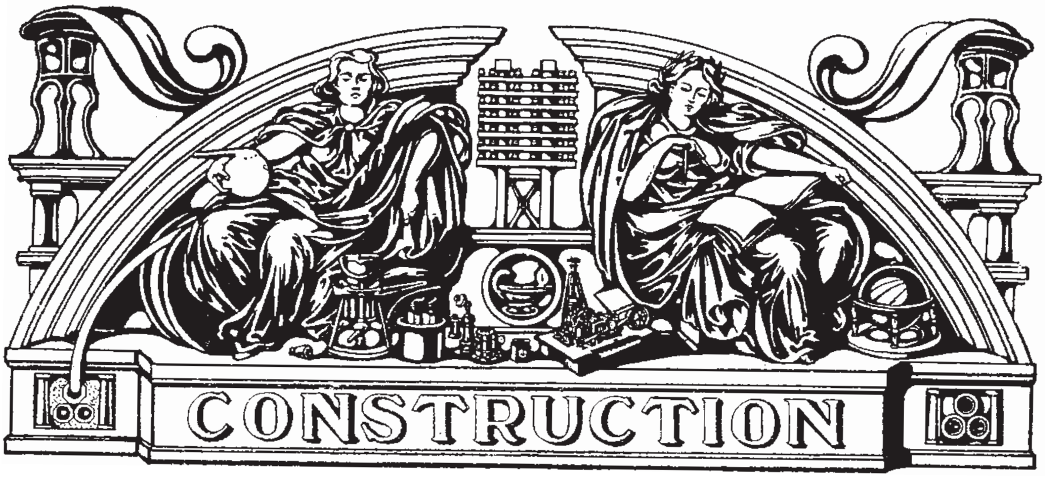
The number of tests to be made on the junctions is as follows :—

On each outgoing junction of a group of junctions to the same exchange one call shall be passed to the terminating exchange.

On one of the outgoing junctions of a group of junctions to the main exchange one call shall be passed to each exchange (auto or manual) obtained *via* the main exchange.

As stated at the commencement, this article is not intended to give more than a brief outline of the tests to be carried out. Specifications giving full details of the tests and testers are sent out for each installation.

Some interesting experiments are being made at the moment with testers designed with a view to cutting down the time at present taken for testing-out automatic exchanges, and it is hoped to describe these in a future article.



SUBMARINE CABLE WORK IN TIDAL WATERS.

By J. S. Brown, M.I.E.E.*

The tidal waters in which the cables referred to later were laid or repaired (mainly towards the end of the war period) are those known as Southampton Water, the Solent, and Spithead: they include the mouths of the harbour of Langstone, with a 5-knot flood tide and a 6-knot ebb tide, and of Portsmouth with tides about the same; Southampton Water with its double tides; Keyhaven with its mud flats; the waters round the Forts of Horseand, Nomans and Spithead with their baffling tide races; the Solent between Gurnard and Stone Point with choppy seas and cross tides; and that exasperating place called The Needles, where heavy weather may delay work for weeks.

The first lesson to be thoroughly mastered before attempting any cable work in these waters is to know the "Tides": some work is better and more easily carried out on the spring tides, some on the neap tides, some at high water and some at low water, according to local circumstances.

Under normal conditions the Submarine Department's cable ships or shore parties would have carried out the works, but as the cable ships were following their occupation in mine-infested waters, it was impossible to make up shore parties from an already depleted staff, and the Submarine Department suggested that it might be possible for the Local Engineer to effect some of the repairs and also lay new cables where necessary. Luckily, the Section possessed two good G.P. Jointers and a large number of old seamen who were well used to boat work and who in some cases had an intimate knowledge of the tides at Spithead and in and around Portsmouth Harbour.

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* Abstract of Paper read before the I.P.O.E.E., in full, on 13th January, 1925.

Naturally all the good craft was in use by the Admiralty and War Department, and for the repairs in the Solent and Spithead it was only possible to obtain boats which were in most cases fairly seaworthy, but absolutely out of date, and not very suitable for the work in hand. An old ship's sailing cutter belonging to Portsmouth Dockyard, about 40 ft. long and 12 ft. beam, was found in one of the Dockyard basins, and this was fitted, as occasion required, with running sheaves fore and aft and the bottom strengthened with planks: it was usually towed on site by a small Dockyard pinnace. When repairing War Department cables an old horse boat was used, and the military daily ration boat for the forts usually towed this craft on site and then went on duty elsewhere, very often not returning until the run had to be made for the harbour before the boom went across at sundown.

In laying and recovering lead-covered cables the method adopted varied according to circumstances, and with special regard to the width of the water and the strength of the tide: in all, four methods were employed.

For laying an armoured lead-covered cable across the River Medina at Cowes—a distance of 220 yards—a primitive but effective method was adopted. A flat-bottomed lighter of sufficient size was obtained from a nearby shipyard, and after jacks had been mounted and secured, so as to give a fair lead over the stern for the cable, the cable drum was lowered into position from a wharf. It was necessary to lay the cable on the top of a spring tide, that is, when there was the greatest depth of water. It was not possible to use the floating bridge for towing purposes and a 2″ rope was therefore taken across the river and kept clear of shipping by means of iron sinkers, one end being made fast to a strong ring in a wharf wall, and the other to an available stanchion. The lighter was then placed in position near the rope, the cable end was taken ashore, and immediately the slack water occurred, *i.e.*, on the top of the tide, the lighter was hand pulled across stream by means of the rope which was passed astern, together with the cable, as the lighter moved forward. By this means the speed of laying the cable could be regulated quite simply, four men being on the drum and 12 men pulling on the rope.

The start was made from the west side of the river and it took approximately seven minutes to lay the cable. On reaching the east side the spare end of cable was lowered overboard and picked up at low water.

In recovering the old cable, which was supposed to have been trenched in to a depth of 6′, it was dug out as far as low water, and then it was drawn across the river by means of double and treble blocks and ropes and luff tackle, the latter being dispensed with as soon as the cable started to move: recovery was effected in two hours.

The *second method* of laying was employed across Langstone Harbour Mouth: the distance in this case between shore and shore is approximately 440 yards and there are no loading facilities available near the terminal points.

It was found possible to hire a tug and a sand lighter, and the latter was drawn up as near as possible to the side of an old wharf. At low water the lighter rested on the mud, and it was necessary to obtain planks and man-handle the drum of cable weighing about 7 tons into position on the stern of the lighter: here it was jacked up ready for running, the jacks were bolted together and secured so that no movement was possible, and arrangements were made for applying brakes to the drum.

The master of the tug decided it would be better to lay the cable on the top of a spring tide, and a start was made from the wharf at Milton (Langstone Harbour) about noon, the landing place on the east side of the Harbour being reached about 20 minutes before slack water. The tide, however, was running so very strongly that the tug was anchored and a rope was got ashore from the lighter which was held fast by the prow, and it was decided, as a very strong wind was blowing, that it would be better, instead of towing alongside, to tow with the lighter astern and stern first.

As the writer was of opinion there might be a quick turn of the tide, the cable was got ashore and made fast, and immediately the slack water occurred the master of the tug raised his anchor and commenced to tow. The actual time taken in crossing was about three minutes and when the western shore was reached the tide had turned and was absolutely racing out. The tug held the lighter up stream until ropes were got ashore for holding the stern of the barge and a good landing was then made. To give some idea of the strength of the tide, I would mention that before the tug master was able to get his lighter into position for towing up stream he was swept seawards for at least half a mile and it was fully half an hour before he passed the point where the cable was laid.

The same method as was employed in connection with the Medina cable, of drawing out the old cable by means of main and luff tackle, was adopted again, but measures were taken to prevent the rope biting into the armouring of the cable and the whole cable was ashore in about three hours.

The *third method* employed was adopted for the laying and recovery of the Itchen Ferry cables, the work, which was necessitated by dredging operations, consisting of the following operations:—

(*a*) Laying a temporary 12-core brass-taped, heavy-sheathed cable, and a temporary 50-pr. 20lb. single armoured lead-covered cable on the north side of the floating bridge; transferring all working wires to these cables; and recovering all existing cables on the south side of the floating bridge and all dead ends.

(*b*) When the dredging was completed, laying a 12-core, brass-taped, heavy-sheathed cable and a 50-pr. 20 lb. double armoured lead-covered cable, on the south side of the floating bridge, and recovering the two temporary cables on the north side.

As all suitable lighters and launches were in use by the Admiralty the difficulty of obtaining craft was mentioned to the Engineer of the Southampton Harbour Board, who said, "Why don't you hire our mooring lifting barge? It is capable of lifting up the heavy mooring chains; come and see it." No sooner said than done; the barge was seen and found to be eminently suitable for the purpose. It is in reality an old gun lighter, 60 ft. long by 20 ft. beam, of very light draught, capable of carrying 30 tons, and fitted by the Harbour Board with a 3″ deck, a good derrick, running sheave forward, 2 strong winches with high and low gear, capable of lifting 6 tons each. There is also a small compartment aft containing a stove, which was found a very great convenience for boiling water for tea and heating meals.

In March, 1918, it was noticed that dredging on the north side of the bridge was nearing completion and a start was made in exposing the cables, usually buried to a depth of 2 ft., between high and low water.

In March (and September) the highest and lowest tides are experienced and mud banks are visible which cannot be seen at other times of the year. On the west side it was necessary to take advantage of this fact to lift the cables from the mud. They were dug out and long wood arms placed underneath them to prevent them sinking again. An ingenious method of labour saving was adopted by Mr. Hill (Inspector), who found that when the bridge was nearing mid stream on the flood tide the bridge cables swung up stream for some distance. Whilst, therefore, the bridge was ashore he fastened a rope to the bridge cable and to one of the Department's cables buried in the mud; as the bridge crossed the river the pull was enormous, dragging the cable out of the mud and saving much digging under very unpleasant conditions. On March 18th, the Harbour Board advised that the dredging was completed on the north side and the temporary cables could be laid. Southampton is well equipped for dealing with heavy goods, and as the heaviest drum to be lifted weighed approximately 8 tons, arrangements were made to use the 12 ton crane on the Town Quay, and on the date named the barge was towed into position under the crane; ropes, chains and all other necessary tackle were got on board; a pair of jacks capable of lifting 12 tons were borrowed from Messrs. Pirelli's and a specially strong steel axle from Portsmouth; the battens were taken from the drums, and the first cable was placed near the crane.

The drum carrying the 12-core cable, weighing 6 tons, was too wide to be accommodated in the hold and it was therefore jacked up on the deck, the jacks being clamped to 8′ brace blocks fastened to the deck and being also secured by 400 lb. G.I. wire to the sides of the barge.

The barge was then towed by the launch as near as possible to the shore, and, after being made fast by means of ropes taken ashore, the end of the cable was run off the drum, over a sheave which had been fixed aft, and taken ashore by hand. A rope had previously been taken forward to a mooring chain in the river and the barge was manhandled to deep water. Two ropes were then taken across to the floating bridge, and on the signal being given to the Bridge Superintendent the floating bridge towed the boat as far across as possible; ropes were then taken ashore by the dinghy and the barge was again manhandled; the actual crossing was in reality about five minutes, but seemed much longer.

Both this and the next cable were laid on the flood tide in order to clear the floating bridge, which swings north on its hawsers when crossing, and the state of the tide did not permit the work commencing until 2.30 p.m., but it was successfully accomplished by 5.30 p.m.

The 8′ drum carrying the 750 yards of 50-pr. 20 lb. cable, weighing 7 tons, was narrower and could be accommodated in the hold of the vessel, which was much safer, as it could not, at all events, go overboard if it broke away.

When a start was made in bringing the cable ashore, one of the centre plates of the drum broke away and the work had to be suspended. An examination showed that the centre was badly affected by dry rot; this was cut away; oak stretchers were placed inside the drum; a new elm centre was fitted, to which the centre plate was bolted, and steel strengthening bands were bolted in position. As the centre plate on the opposite side of the drum also showed signs of shearing through the wood, this was taken off and two stout pieces of elm were bolted in position. The work of repairing the drum and getting it into position again on the jack occupied 15 hours—and the tide was lost for the day.

The cable was successfully laid before 6 p.m. the following day, and the jointers by working all night completed the transfer of the working circuits to both temporary cables by the time the barge was in position ready for lifting the cables made spare on the south side.

The 102-pr. armoured lead-covered cable was first tackled, and was underrun from the shore and heaved on board by using the derrick. The end was coiled on the large drum from which the last cable had been uncoiled, six men manning the drum at this period. The recovery now proceeded by bringing on board over the forward sheave by means of the steel winch ropes and three and sometimes four men were required on the winches, sling chains being used to obtain a grip on the cable and short fleets being made. The actual time occupied was from 10 a.m. to 4 p.m., with a short interval for lunch, and the work was very heavy indeed owing to its completion being necessary before the tide took command. The boat's head was kept fairly well in position by the heavy cable, but when the rear ropes became too long to handle or were in the way of traffic, kedge anchors were used for keeping the stern straight. The cable was raised without damage. It weighed approximately 7 tons, and all spare hands had to be on the drum to coil the last 100 yards.

In recovering the old 4-core cables it was found the sheathing had become too brittle to allow of them being coiled on drums. They were therefore brought inboard and coiled on deck.

The permanent cables were laid in the same way as the temporary cables, but in recovering the latter it was found possible to redrum them as they were brought inboard.

The *fourth method* was employed recently in laying cables across Portsmouth Harbour between Portsmouth and Gosport—a distance of 740 yards.

A lighter propelled by its own power, and specially fitted since the War for cable work by the Admiralty in the immediate neighbourhood of Portsmouth, was hired from the Dockyard Authorities. It was originally one of the boats used for landing troops on the coast of Gallipoli; consequently it is a fine roomy vessel and can accommodate large drums of cable in the hold, but the power unit is not large enough to hold the boat in position with a cable astern and any tide running.

The drums of cable, each weighing 9 tons, were mounted on jacks in the hold and the cable paid out, nearly astern, over a greased boom. The lighter, being of fairly shallow draught, was able to get within 100 yards of the shore on the Portsmouth side and about the same distance on the Gosport side. The getting inboard and the mounting of the jacks and placing the drums in position required much thought and care as regards detail.

The cables were laid at low water on the neap tides, and great precision in the arrangements was necessary, as if delay had occurred the flood tide would have carried the lighter (which can only proceed about 7 knots under its own power) over the Gosport Ferry cable chains, and this would have been disastrous both to the cable and the working of the Ferry.

In laying the second cable extraordinary luck was experienced. The cable end had just been taken ashore on the Portsmouth side when a Swedish man-of-war entered the harbour and proceeded to its mooring, accompanied by a tug. The usual formalities of gun firing, saluting, etc., were carried out and this always means very slow progression. Immediately this vessel had passed up the harbour it was decided to lay the cable and orders were given accordingly; the cable laying was just completed and the Gosport side reached when the seaplane-carrier, "Argus," entered the Harbour. If the "Argus" had been ten minutes earlier the cable laying would have been delayed half an hour, the tide would have been in flood, the cable end would have had to be taken aboard, and the next neap tides awaited.

Laying and recovering G.P. submarine cables.

In laying G.P. submarine cables, which are generally received coiled in railway trucks and not on drums, the method employed is to use a flat-bottomed lighter sufficiently large to accommodate the cable coiled in a figure 8. The coiling of the cable in this form enables it to run off smoothly over the stern of the lighter and does not require men stationed round the coil to keep it in place. It certainly takes some little time to coil in this way, but it has been found to be more economical in time when using the type of vessel available. Having coiled the cable at any convenient wharf in the lighter, a motor launch, steam or otherwise, is hired to tow the lighter to the first landing point, generally an oilship lying in the river.

Having got the end safely on board the vessel to which communication is desired, a large iron sinker is chained to the cable to anchor it near the vessel, this being necessary as the oil ships swing to moorings fore and aft. The lighter is then towed towards the shore, the cable being paid out over the stern.

Usually the towing craft has required 6′ to 9′ of water and naturally could not tow quite inshore. Having gone as far as possible, the lighter is held until a rope is got ashore by means of a boat, the land party then pulling in the lighter by hand and landing the cable end.

This method is typical and the only special point to be watched is that the craft is suitable to take the length and weight of cable to be laid. It is always safe to err on the large side so far as the lighter is concerned.

In one or two cases the G.P. cable has been received on a drum and one of the methods already described for laying lead-covered cables has been adopted.

Repairing armoured lead-covered cable.

Only on two occasions has it been possible to repair lead-covered submarine cables.

In the first instance, a cable which crossed the Medina River at Cowes was slightly damaged, and it was found necessary to cut in a new section of about 80 yards from one side of the river. An old ship's lifeboat was hired, the new piece of cable brought on board, and the good end of the existing cable was underrun and made fast on board. The lead sheaths of both old and new cable were stripped back for about 10 feet and a paper core joint was made in the usual way. A very long sleeve, however, was used. After the wiped joint was completed the lead sheathing was wrapped with adhesive tape for a distance of 6 feet on each side of the joint; this was covered with prepared yarn, the steel tapes were laid in position, and the sheathing was then spliced and bound in. (The method of overlap and splice jointing is described later.)

The second repair to a lead-covered cable was carried out successfully on the Itchen. The damage occurred at a point between high and low water mark and before the tide rose it was possible to protect the exposed end sufficiently by means of cycle tyre tubes to prevent the water entering. At low water the cable was pulled back into position, first by means of main and luff tackle and then with the help of the floating bridge. The damaged end was cut away and the cable is still working satisfactorily.

Repairing G.P. Submarine Cables.

During the winter of 1917 and 1918 many of the G.P. Submarine Cables were damaged, principally by boats having to drop their anchors, and it became necessary to undertake a considerable number of repairs.

The same method was employed in each case, and a general description of the way the work was carried out is as follows:—

In practically all cases both ends of the cable were accessible, and localising tests were made by means of the Wheatstone Bridge, the distance of the fault usually being obtained fairly accurately. As grappling is a difficult process with an open boat and in strong tides, an effort was always made to pick up the end and if this succeeded the cable was underrun until the fault was found.

If the cable was broken the broken end was buoyed and usually the other end of the cable was grappled for or underrun from the other side until the second end was secured. Generally 50 to 100 yards of new cable was carried in the boat in case sufficient slack could not be picked up for jointing.

In making the joint the sheathing wires on both ends of the cable are first opened out for a distance of about 8 yards and the exposed core cut away, with the exception of 4′ required for jointing.

The conductor joint is next made. The insulation on each core is removed for 1½ inches, the copper strand is opened out, each of the seven wires is scraped and cleaned bright with glass paper and then twisted up again to form a strand as before. Each end is soldered and trimmed and is then filed down obliquely on one side. The rough corners left by the solder are filed off and smoothed with glass paper. The ends are now clamped in a jointer's tray and brought close together, fitting truly and presenting a bright silvery appearance, and the joint is bound with fine copper binding wire to within ¼ inch of the clamps on each side, the binding being of open spacing to allow of removal after the solder has been run in. A neat solid joint is thus made and, after removal of the binding wire, a close binding is laid on in the middle part of the joint and soldered; a second wrapping is then laid on to near the clamps on each side and this is soldered at each end only and close to the clamps; and finally the joint is smoothed off and cleaned of the soldering fluid by rubbing with a rag soaked in naphtha, and is then ready to receive its insulation.

To insulate the joint it is first given a complete coating of Chatterton's Compound, which is smoothed with the smoothing iron and worked over with the finger and thumb to ensure that there are no air bubbles in the covering. The gutta percha of each core is then warmed up and drawn until the ends are about ½ inch apart; one end is then drawn down to a point and the other end worked over it, completely covering the copper joint and, after being warmed up and well smoothed down, a serving of compound is given to the gutta percha.

A strip of gutta percha, 3 inches by 1½ inches is next warmed up and, one end being laid under the joint, is worked from one end to the other, in one direction only, with an upward pressure; it is again warmed up and worked round the core until every part is completely covered; the overlap above the joint is nipped together and cropped by scissors close to the core; then it is again warmed up, worked, and smoothed over.

A second strip of gutta percha, about 6 inches by 1½ inches, is next laid on and worked in the same way, so as to taper on to the core on either side. It is given an additional coating of Chatterton's Compound, again smoothed over by rubbing with the hands well moistened.

The completed joint, with the copper conductor well centred and with a complete fusion of the layers, measures from 6 inches to 9 inches long and is very little larger in diameter than the core.

It is important to mention that the cores are cut so that the joints can be " staggered," *i.e.,* spaced, and thus avoid damage by compression when the core is re-covered by the sheathing. In cables up to 8 cores the distance apart is generally about 6 inches, but in the lighter types, or with a greater number of cores, 4 inches is sufficient. Great care is required to cut the wires to the correct length, otherwise, when the set of joints has been completed, there may be a slack or tight wire. A good and convenient method is to cut out the cores with the help of a 6-inch measure.

When the core joint has been completed it is first covered with cotton tape, then with brass tape, and finally with jute yarn. In splicing the sheathing the wires on one side of the joint are laid out in twos and threes, wound in turn round the yarn-covered core and then over the sheathing wires on the other side and as they are carried round into position they are bound with soft iron lapping wire at intervals to prevent any springing out of position. The sheathing is then served with tarred yarn by means of the serving mallet.

The splice just described is known as the " overlap " splice, but the " butt," or " laid in," splice was generally made by the local staff. For this splice the ends are prepared in the same manner as for the " overlap," and the cable end from which the core has been removed is called the " long end " and the other the " short end." When the joints have been covered in, half the wires on the " long end " are laid in as far as the sheathing wires of the " short end " and then unlaid in pairs. One pair is selected and laid on the " short end " after a corresponding pair has been removed. The first pair is carried to the full length, cut off and trimmed so that the butted wires are on the top; they are easily trimmed off with bolt clippers and " butted " so as nearly to touch the ends of the pair cut out on the " short end." A piece of tarred tape is then served over the " butted " ends, three inches on either side of the " butt," followed by a lapping of G.I. wire No. 14. The next pair is then taken and laid in the same way and " butted," say, a yard and a half from the first pair, and so on until the last pair, which is " butted " just clear of the joints. In this way the joints are clear of the " butts," which are all on the " short end." The distance apart of the " butts " depends on the length of the splice and the number of sheathing wires. In the case of short splices made in boats, three or four wires may be " butted " instead of two and the splice will still be extremely strong, provided that the lappings have been tightly served on with a mallet.

Testing (a) New lead-covered cables and (b) Submarine cables before and after repairs.

In testing lead-covered cables the same method is employed as for ordinary underground cable; insulation is tested wire-to-wire and wire-to-sheath by means of a 500 or 250-volt megger and should give results beyond the range of the scale; resistance is tested by the Wheatstone Bridge to one or two places of decimals as the distances are short; for contact and overhearing, tests are made by means of the Detector and Buzzer.

In testing for the distance of faults on G.P. cables where both ends were accessible, a simple ratio test was first tried and this was usually confirmed by the Varley test, the Wheatstone Bridge and 10 to 20 cells being used in both cases. In making these tests peculiar results were sometimes obtained, due to electrolytic action between the exposed copper conductors, the sea water and the brass sheath, which formed, at the exposed end, a small battery sufficiently strong to give misleading figures. After the repairs and 24 hours' immersion, tests for insulation and conductor resistance were made by means of the Wheatstone Bridge; no capacity tests were undertaken at any time.

The experience gained on this class of work has led the writer to the following conclusions:—

(1) Every step in the preparations for cable laying must be carefully considered, and it is well to visualise the whole proceeding from start to finish. No detail must be overlooked; the fraying out of a single rope, or, when dealing with heavy drums, a loose timber, badly placed jacks, wire lashings not firmly secured, etc., may lead to disaster.

Once the officer in charge of the work has decided that all has been done to carry the work to a successful conclusion the remainder can only be left in the hands of the gods.

(2) In both laying and repairing cables it is absolutely necessary to have only one officer in command, and this officer must make quick and bold decisions if things go wrong.

I should like to place on record my thanks to the Brothers Bordeaux (Submarine Superintendents) who were always willing to give advice and help when appealed to.

WIRELESS

RUGBY RADIO STATION.

By T. WALMSLEY, B.Sc., Assoc.M.Inst.C.E.

To the popular mind, wireless aerials and masts conjure up visions of unsightly wires slung upon protesting branches of trees or anæmic clothes props. Undisturbed by thoughts of stress and strain and regardless of factors of safety, the wireless amateur broadcaster cheerfully attaches his wire to the most convenient fixing and, although the harmony of his happy home may sometimes be rudely broken by the pointed comments of the lady who has promised to love, honour and obey him, the enthusiast pursues the even tenor of his way, wholly contemptuous of Euler and his satellites. Not so the wireless mast engineer. Each icy blast of March sends cold shivers of apprehension down his spine, causing him pangs of regret that he did not double his already high factor of safety. Mentally he vows to add those extra bracings that, when gentle summer breezes blew, he had decided to omit in the sacred cause of economy.

Here at Rugby, where eight of the twelve steel lattice-work masts have been completed, the recent gales have emphasised the wisdom of adopting large factors of safety. Viewed through a telescope, the top of a mast has been seen to oscillate three feet beyond a central position about its pivotal base. The design, however, provides for a deflection of eight feet, and even when this is obtained factors of safety of from 3 to 6 still give ample margin of security. Careless workmanship, however, might cause catastrophe, so careful supervision of the quality of workmanship, both in the shops and on site, must be maintained. Masts 820 feet high, supported on porcelain insulators and granite blocks, are extremely imposing, but behind this spectacular effect lies a vast amount of exact calculation and planning. Before the work of erection could begin, a suitable site had to be found and boreholes made to determine the suitability of the sub-strata to withstand the great concentrated load of masts whose maximum downward thrust is 400 tons. A careful survey was necessary, transport facilities had to be made and an efficient but flexible testing and supervising organisation had to be undertaken. Months before the masts began to be conspicuous landmarks, a vast amount of ground work was completed. It was essential that the

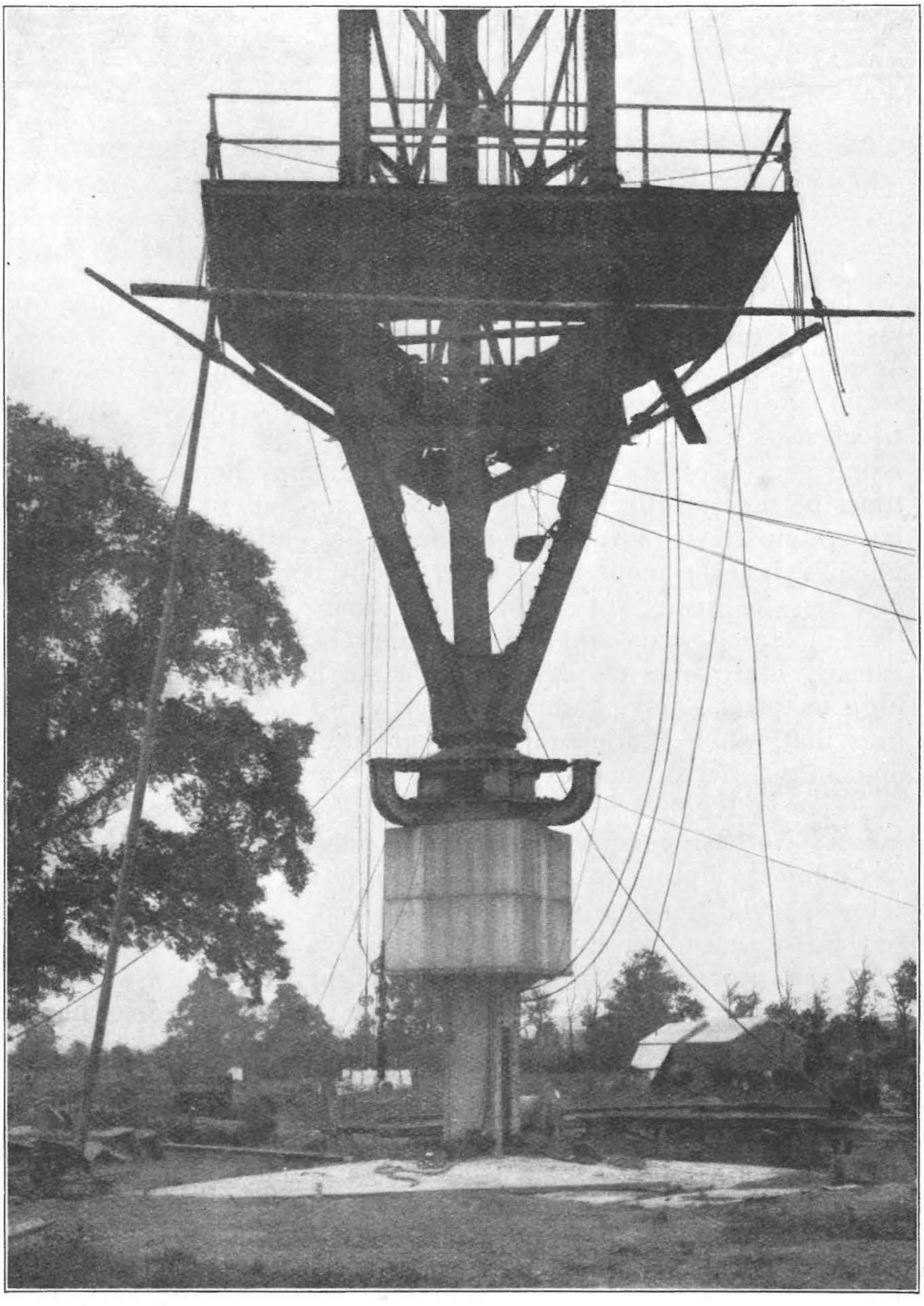

FIG. 1.—BASE OF MAST, SHOWING STEEL STANCHION, GRANITE BLOCKS, PORCELAIN INSULATORS AND BALL SOCKET.

porcelain insulators upon which the masts stand (see **Fig. 1**) should be tested electrically, but no testing plant existed with which to make the requisite tests, without interfering with the running of plant in other Radio Stations. The Department, therefore, installed at Rugby a steam-electric plant of 100 Kilowatt capacity. To convert the 500 volt direct current into high frequency current, an electric arc with oscillating circuit, was fixed, old departmental plant being used for this purpose. Up to the present moment, some 2,000 insulators have been tested with a voltage of over 15,000, the frequency being 50,000 cycles per second. The application of this voltage and frequency to defective insulators has, in some cases, occasionad so high a rise in temperature that the material has become like molten lava. No insulator has been passed if any appreciable rise in temperature has been observed after a period of over one hour.

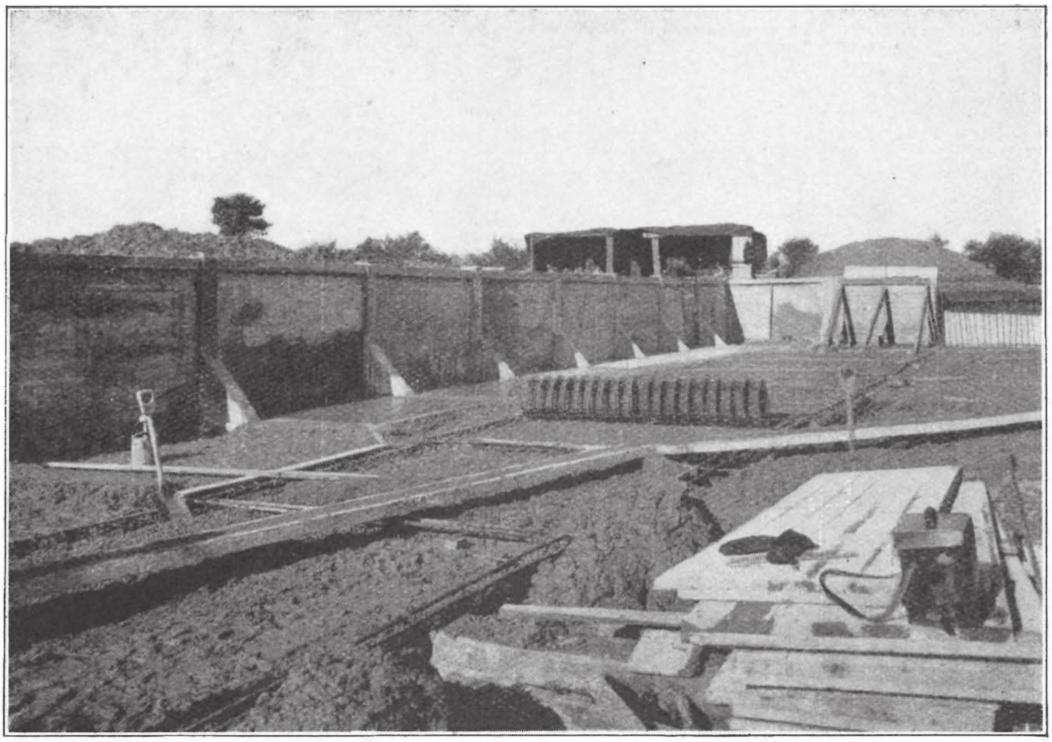

FIG. **2**.—500,000 GALLON FERRO-CONCRETE RESERVOIR IN COURSE OF CONSTRUCTION.

Some idea of the magnitude of the constructional work involved will be gathered from the fact that about 8,000 tons of concrete have been needed for the mast foundations and the anchor blocks to which the stay ropes are attached. In addition some 700 tons of concrete have been used upon a ferro-concrete reservoir (Fig. **2**). This reservoir, designed and built by the Department's staff, is required to hold 500,000 gallons of water required in connection with the cooling system of the transmission valves with which the station will be equipped.

All stay ropes for the masts were made on site, special plant being needed to draw out, two by two, the 150 wires required in the largest stays. These wires were then drawn together by mechanical appliances and bound tightly round with steel wire. The ends of the stays were bent over and fitted into tapered sockets, one of which is shown in Fig. **3**. A low temperature melting metal was then run into the socket to bind securely the ends of the wires.

Concurrently with the work of erection of the masts, the aerial has been prepared and the earth system partially completed. The aerial is in the form of wire "sausages," supported by means of steel spreaders, 12 feet in diameter, clamped on to a central steel cable. When in position on a calm day the tension in the central cable will be 6 tons, but this figure will be exceeded considerably when a strong wind blows. The mast itself is designed for a top horizontal pull of 10 tons and precautions have been taken that this pull shall not be exceeded, by fixing a slipping device to the drum of the aerial winch. Wires have been laid a few inches under the ground by means of a special plough (Fig. **4**) designed and built by the Department's staff. The plough is such that in a single operation a narrow trench less than an inch wide is cut in the

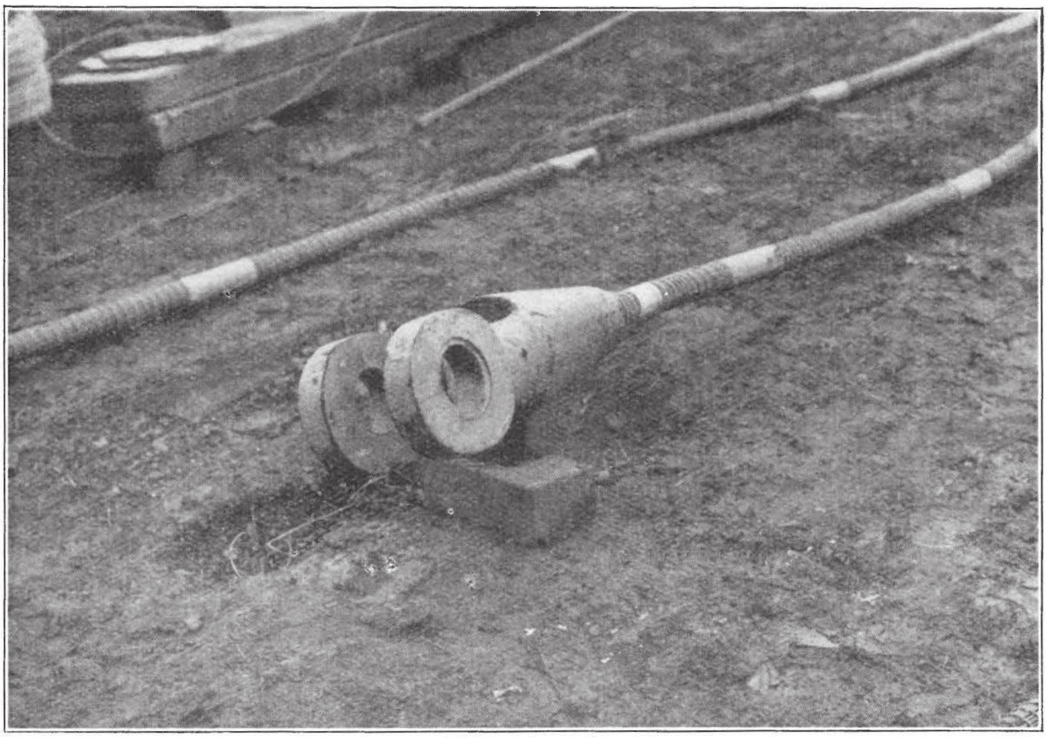

FIG. 3.—SOCKETS AT END OF STAY ROPE.

earth, a wire is laid down and the trench partially closed. About 80 miles of wire have been so laid

The Station is fittingly termed " the Radio " in preference to " the Wireless." Wire will be everywhere, quietly lying in the earth, gently swaying aloft, and revolving in large motor generators. In the stays alone, 3,000 miles of wire have been used, and if the total lengths of copper, phosphor-bronze and steel wire used in the construction of the Station were totalled together, the sum would be sufficient to build a single line to the Antipodes.

Of the anxieties and humours of erection, much could be said. The former try to forget, the latter we cherish as good friends.

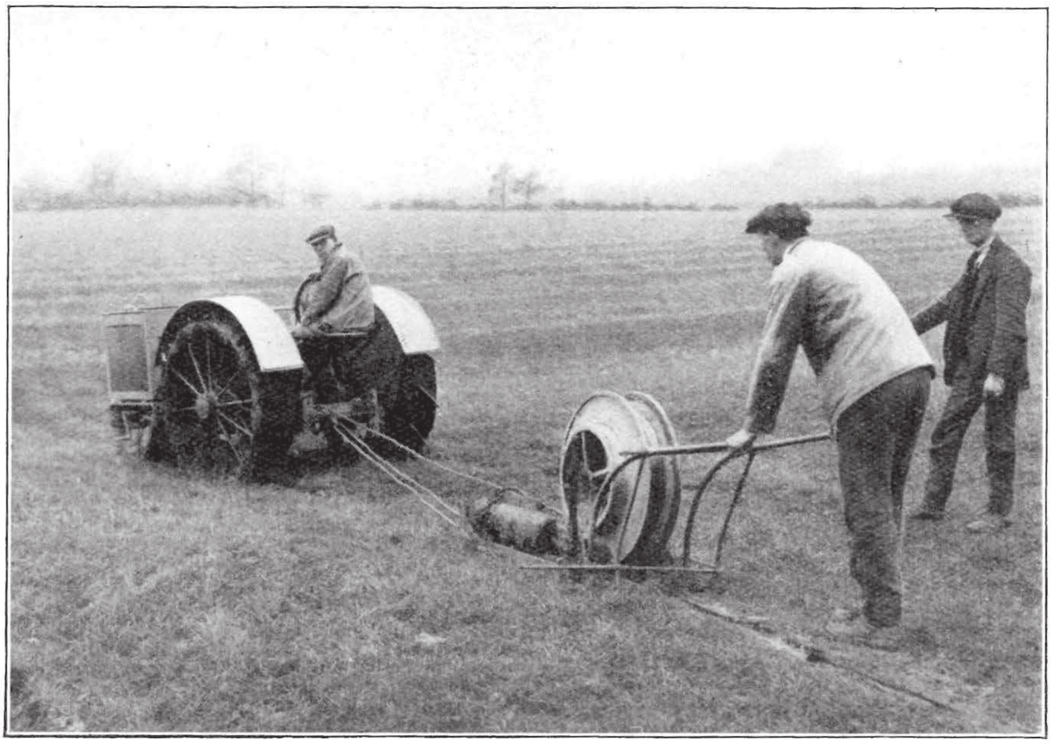

FIG. 4.—WIRE-LAYING PLOUGH.

One can picture the difficulties and dangers of working hundreds of feet above the earth. One such danger is illustrated in the photograph (Fig. 5), showing a man stepping across from a platform to a ladder, which swings from its temporary holdings 20 feet above him. Below is a clear drop of 700 ft.

After a little experience, the workmen adapt themselves wonderfully well to the dangerous conditions. Each mast has its leading hand and each leading hand has his own methods of dealing with his assistants. One such leader is a man of simple speech and many adjectives. Upon occasion his remarks are more lurid than polite and his verbal broadcasts are only appreciated by those not concerned. One day, two of his victims stood silently watching him emulating the monkey tribe. As his leader reached the top of a mast, Bill feelingly remarked to his companion, " Arry, that's as far as 'e will ever get to 'eaven."

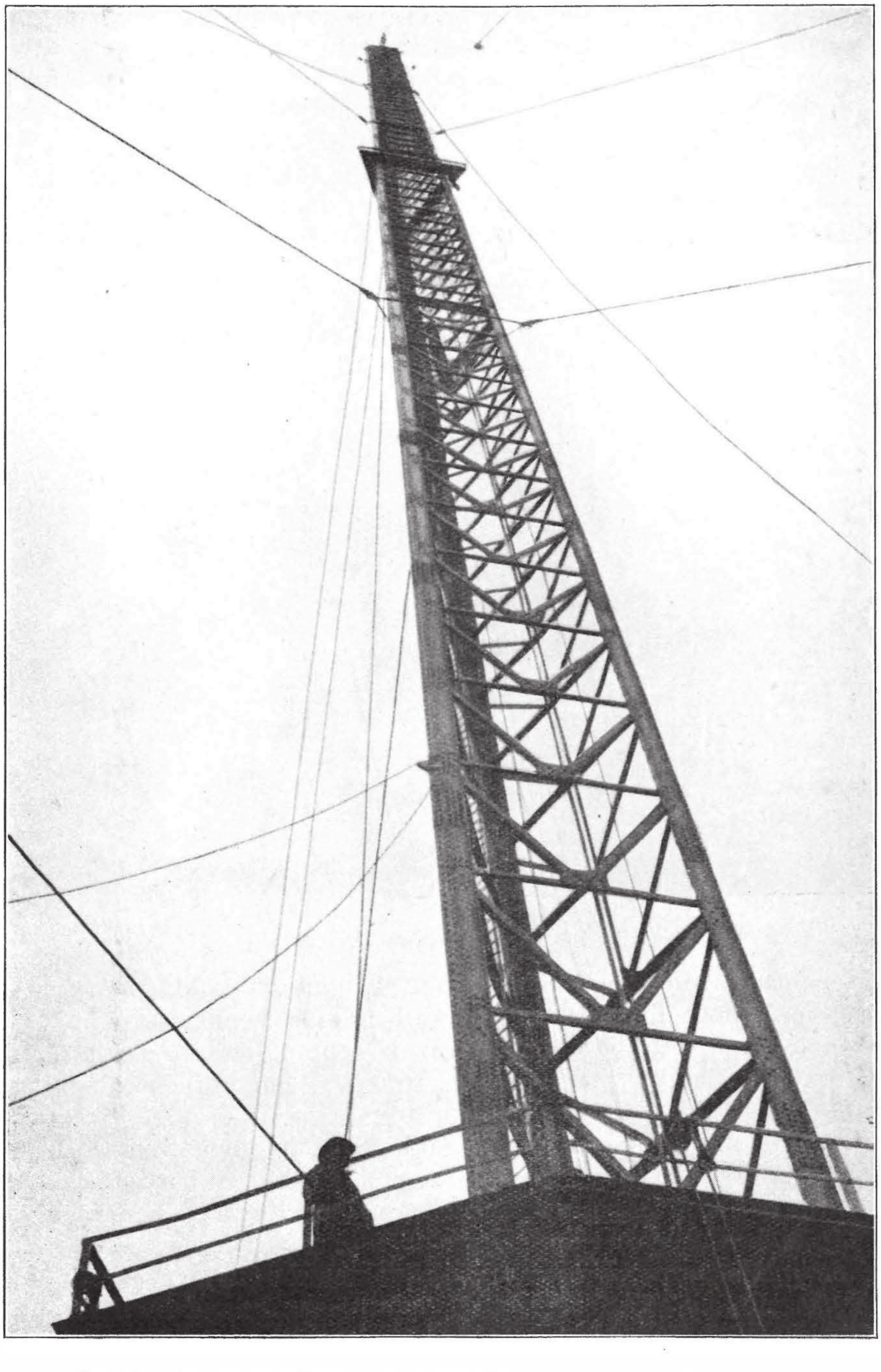

FIG. 5.—ONE OF THE MASTS : LOOKING UPWARD FROM THE GROUND.

Men foregather at the Radio Station from all parts of the British Isles. The broad sing-song dialect of the North blends with the monotone of the South; the staccato of Wales harmonises with the adagio of the Midland Counties. Excavators are mostly local men, steeped in local tradition and practice.

In spite of the many delays experienced owing to strikes and bad weather conditions, the work of erection of the Radio Station is proceeding smoothly. The spirit of good fellowship that exists between workers of all ranks augers well for the success of the project. When, in the near future, the thrilling moment arrives for messages of goodwill to wing their flight to the furthermost corners of the earth, each toiler, in his own sphere, will truly feel that something has been attempted, something done.

THE TESTING OF INSULATING MATERIALS FOR USE AT HIGH FREQUENCIES.

SINCE certain of the porcelain insulators inserted in the stays supporting the masts at the Leafield Radio Station began to melt for no very apparent reason, a very great interest has been taken by the Engineering Department in the behaviour of various insulating materials when subjected to the influence of strong electrostatic fields alternating at high frequencies. It was at once realised that laboratory measurements of power factor, insulation resistance, etc., would not give a complete indication of the value of a particular material for high frequency work. This will perhaps be more readily realised if the effect be considered of a small amount of impurity, having heavy dielectric losses, embedded near the centre of a mass of insulating material which is also a very poor conductor of heat. If such a body were tested for power factor and insulation resistance it is quite probable nothing untoward would be observed. If, however, it is subjected continuously to a very strong high frequency electrostatic field, heat will be generated. This heat, imprisoned in the heart of the material, will have no easy means of escape and the internal temperature of the body may rise continuously until the material itself fractures, melts or burns in accordance with its particular physical characteristics.

A definite practical test is therefore essential, sufficient power being used so that applied voltages are not considerably reduced by any losses in the test pieces. The Poulsen Arc high frequency generator lends itself admirably to this purpose. It is very robust and is unaffected by the sudden breakdowns, flashings-over, etc., from which tests of this nature are inseparable. The arc installation at the Northolt Radio Station was requisitioned, at such times as it was not required for commercial traffic, for most of the early work, which was carried out by Mr. G. T. Evans. The arc is capable of supplying to the primary circuit about 10 k.w. of high frequency power and will produce a normal voltage of 26,000 V., which can be increased if necessary to a maximum of 35,000 V at a frequency of 43,000 cycles. The oscillation circuit itself consists of a Dubilier Mica Condenser of 0.005 μ F capacity and an inductance made up of $\frac{5}{8}''$ diameter copper tubing, the coil being 6 feet in diameter and approximately 10 feet high. The material to be tested is placed between two copper plates connected across a portion of the tuning inductance, as is indicated in the diagram of Fig. 1. The high frequency voltage applied to the sample under test can be varied either by moving the tapping point or by the control of the D.C. supply voltage to the arc, and is known by reference to the H.F. current in the oscillation circuit, the inductance and the frequency. This voltage can also be checked by means of an electrostatic voltmeter. The temperature of the test piece is kept under observation throughout the test by means of an ordinary thermometer, the bulb being placed in intimate contact with the surface of the material and protected by means of asbestos, or (in the case of wood and similar materials) inserted into a small hole drilled into the sample. Readings of rise in temperature of similarly shaped bodies under the action of the same field give a very ready, though perhaps somewhat rough, idea of relative quality.

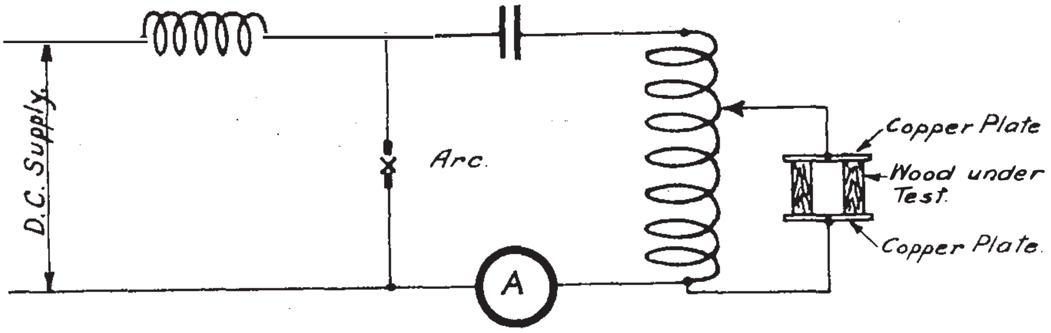

FIG. 1.—TESTING CIRCUIT.

The tests which follow were in the nature of preliminary tests in order to ascertain the best materials for use for the insulation of the masts and stays at the Rugby Radio Station, and also to determine the most suitable material for the manufacture of high power tuning inductances. In the first mentioned case, it was necessary that good dielectric properties of the material should be combined with good mechanical properties, as some of the insulators were to be called upon to support a maximum load of 400 tons.

The following schedule gives examples of the results of preliminary tests on materials considered for mast and stay insulation, the frequency being 43,000 cycles in each case:—

Material.	Dimensions cms.	H.F. Volts, R.M.S.	Duration of Test.	Temp. rise during test.	Remarks.
British Granite	11×8×3	23,000	Few Secs.	95°F.	Broke down immediately the voltage was applied.
Norwegian Granite, coarse grain, dry	10×9.5×5	21,000	5 hrs.	59°F.	O.K. at end of test.
Do. do., after immersion in water for 30 minutes ...	10×9.5×5	3,200	3 mins.	100°F.	Test discontinued owing to rapidly increasing temperature.
Norwegian Granite, fine grain, dry	10×9.5×5	21,000	5 hrs.	48°F.	O.K. at end of test.
Do. do., after immersion in water for 30 minutes ...	10×9.5×5	3,200	3 mins.	73°F.	Test discontinued owing to rapidly increasing temperature.
Cornish Granite ...	15×15×8	17,000	10 mins.	90°F.	Test discontinued owing to rapidly increasing temperature.
Aberdeen Granite ...	10×9.5×5	21,000	5 hrs.	102°F.	—
Staffordshire Bricks, dry (*a*) Wire cut (*b*) Moulded	23×11.5×7.5 ,, ,, ,,	8,500 10,000	30 mins. 30 mins.	96°F. 75°F.	—
Staffordshire Bricks, after immersion in water (*a*) Wire cut (*b*) Moulded	23×11.5×7.5 ,, ,, ,,	7,000 7,000	2½ hrs. 2½ hrs.	160°F. 13°F.	Temperature was constant during the last hour of test.
Porcelain, dry	17 diam. 10 high solid	25,500	3 hrs.	—	Temperature out of range of thermometer at end of test.
Do. do., after immersion in water for 30 minutes ...	17 diam. 10 high solid	25,000	45 mins.	—	Became molten internally, cracked and molten porcelain exuded.
Porcelain, solid, after 20 hours immersion in water ...	30 diam. 15 high	15,000	—	130°F.	
Porcelain as above, but with central hole 10 cms diam. ...	30 diam. 15 high	30,000	—	25°F.	Temperature began to fall after reaching max. and remained steady at 20° rise for one hour.

Fig. 2* shows the results of a test on a number of different kinds of wood required for use in manufacture of large inductance coils. These samples, each 4″ × 1″ × 1″, were subjected to the test simultaneously, the voltage being gradually raised. The name of the wood is shown against the point on the graph of voltage and time at which it was necessary (owing to burning, etc.) to remove it from the test. Points A and B indicate the approximate relative merits of two well known proprietary materials of synthetic resin and cellulose, which are generally regarded as of special value for high frequency work. It is now the practice of the Department to test in this manner samples of all insulators which are to be used under high frequency conditions, and many hundreds of samples have been so tested in the temporary testing plant installed on the site of the Radio station now in course of erection at Rugby.

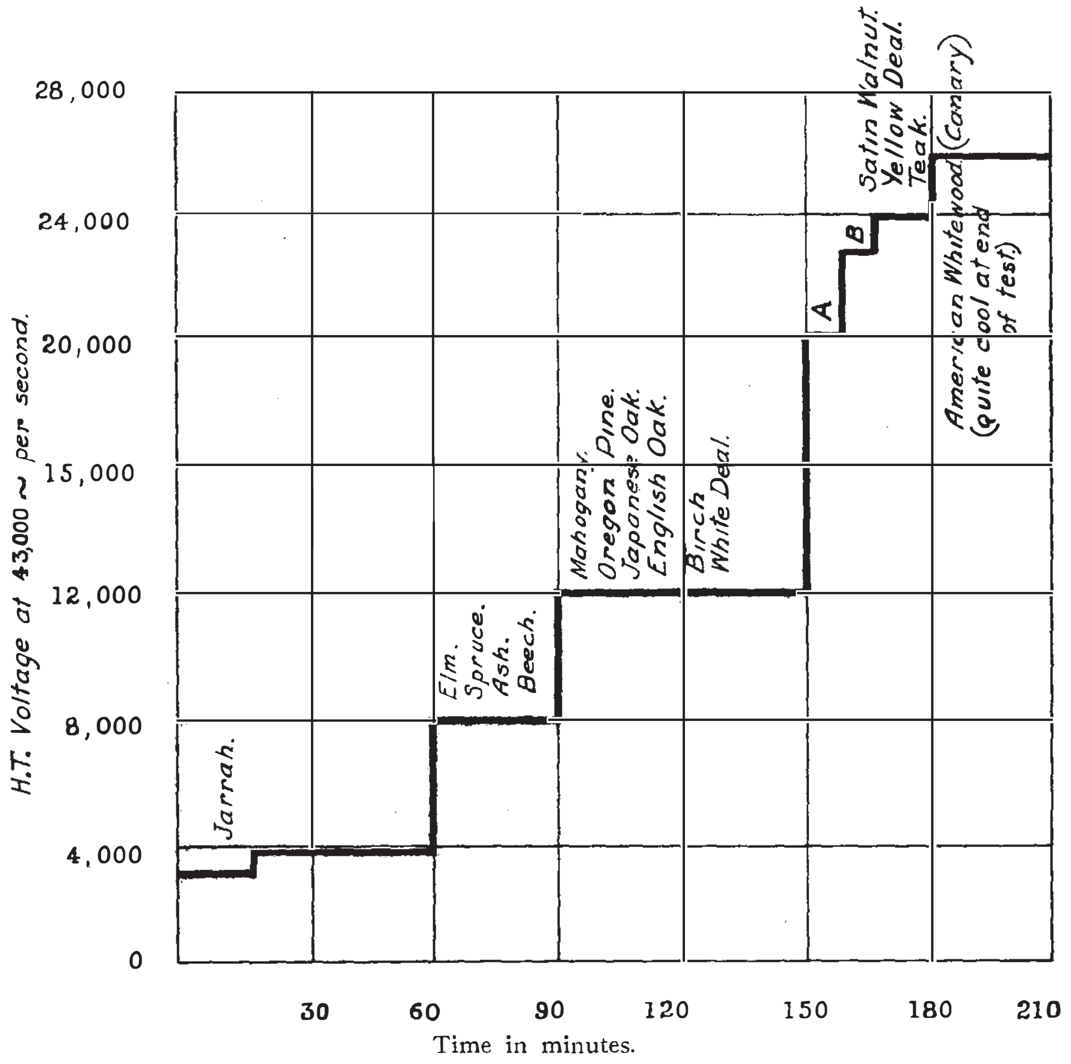

FIG. 2.—TESTS ON VARIOUS TYPES OF WOOD.

H.F.

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* See also E. H. Shaughnessy, *Journal I.E.E.*, 1925, Vol. 63, p. 61.

NOTES & COMMENTS

NOTES AND COMMENTS.

MR. DONALD MURRAY'S paper on "Speeding up the Telegraphs: A forecast of the new Telegraphy," had a favourable reception when read at the Institution of Electrical Engineers in December last. He describes it as mainly a forecast of the probable form that the telegraph will take in the next 25 years.

He who would adopt the role of prophet must needs be an enthusiast and one with strong convictions, especially on such a highly technical question as this undoubtedly is. Mr. Murray is more than this, because after advocating the "Automatic" system (high speed single channel working) for a number of years he had the courage to change his opinions and become a supporter of the "Multiplex" system. The change is entirely in his favour, as only a strong man can do this and cannot but command our respect.

Mr. Murray now advocates a telegraph exchange system. This, of course, is not a new idea, as we have seen several essays in the same direction, for example the early Umschalter system of the old Electric and International Co., the Wheatstone A.B.C. exchange at Newcastle-on-Tyne, the Intercommunication Switch at the C.T.O., designed by Colonel Purves, and the Telewriter Company's Exchange in London. The new feature in connection with Mr. Murray's proposal is the use of the "Start-Stop" printer.

The apparatus is a very suitable instrument for placing in the business man's office in order that it may be manipulated by his typing staff. As far as our experience goes it has done its work very well, but if its use be extended it will mean a considerable increase in the staff of mechanics and will create quite a new industry in the same way as the ordinary typewriter has done. Its maintenance will not be less simple, and the introduction of long distance transmission will not render this phase of the matter less difficult.

Mr. Murray states there is no shortage of telephone messages. One of the difficulties of both the telephone and telegraph services is to provide a uniform load for the plant during and after business hours. The telephone rates are varied to induce the public to distribute the existing load over a longer period, but business men are prone to confine their communications to normal working hours and even to concentrate on only a few of them. The only people who wish to use the telegraph service at night time are the newspaper proprietors and they are encouraged to do so as much as possible by cheaper rates for the use of night circuits.

Another point mentioned by Mr. Murray is that the telephone needs two costly wires while the telegraph needs only one. This may be true for aerial lines, but even in this case it is possible to provide more than one circuit on the telephone loop whereas the telegraph line does not lend itself so readily to such an arrangement. When, however, long underground cables are used the telegraph needs two wires so that in this case the comparison does not hold. Doubtless in the future all telegraphs, that is, the main circuits, will be underground in order to provide surety of communication (we have gone a long way in this direction already) which is one of the most important factors for a really efficient service.

It must be borne in mind that the diversion of an aerial circuit to the underground almost invariably leads to a reduction in the speed of signalling.

Mr. Murray refers to the great farming industry. Speaking of this country alone, the individual farmer is not a great patron of the telegraph and is not likely to indulge in private teletype circuits. The purely business messages connected with farming are few and as these alone justify typewriting telegraphs the outlook in this direction is not a very hopeful one. Even the cheap telephone which, apart from business transactions, can be used for social intercourse between farm and farm is not nearly so much utilised as it might be.

The transfer of the cost of operating to the subscriber is, of course, a very alluring one, as this is the most serious item so far as the Post Office is concerned. According to the Accountant-General, about four-fifths of the costs of dealing with a telegram are due to operating charges; this fact is enough to spur all engineers to special efforts with a view to eliminate some of them. Much has already been done and if the "Start-Stop" will assist in this direction, and there is good reason to think it will, the engineer will do his best in the matter.

Mr. Murray states plain multiplex working duplex can give twelve channels on a single wire without difficulty and there is nothing inherently impossible in working the ordinary multiplex up to twelve channels each way. This is 100% more than anything yet done on a stable underground circuit. Much, of course, depends on the length of the line, but this point is not mentioned and might mislead the uninitiated.

The calculations given by Mr. Murray on page 18 of his paper make no mention of the capital cost of the multiplex apparatus that would be required at each end of the line, nor of the attendance for running and maintaining it. This charge would be additional to the teletype exchange maintenance and operating.

At 40 words per minute twelve arms would mean 480 words per minute duplex. Between London and Birmingham we have obtained 180 words per minute duplex, six arms at 30 words per minute, so that although the teletype would be working at the lowest speed quoted by Mr. Murray, the figures are pretty high. The duplex balance would have to be exceptionally good and the phase running of the two distributors very exact. On the same page Mr. Murray mentions that so long as we don't expect too much from telegraph machinery and human nature we have good reason to be hopeful.

Speaking of the speeds at which the Start-Stop printers should be run, Mr. Murray mentions three possible speeds. Seeing that in order to get intercommunication between different circuits working on the multiplex system a common speed is necessary, it would appear that the teletype should be made to conform to it. Several advantages would be obtained, more channels per circuit would be obtained at, say, 40 w.p.m. than if the speed were higher, maintenance would be cheaper and in the long run the subscriber would be more satisfied with an instrument that ran well at low speed than with an indifferent one at a higher speed. Speed changing gears should not, it is thought, be encouraged. Time would be lost and so would tempers.

THE TRANSMISSION UNIT.

It is very desirable at the present time, when international telephony on a large scale has become a practical proposition, to establish a uniform unit of transmission in terms of which the efficiencies of telephone transmission lines can be expressed. There has been a considerable amount of discussion in the technical press and elsewhere on the choice of this unit and the matter is now under consideration by the International Electro-Technical Committee. These notes are intended as a summary of the present position. For further details reference should be made to the articles which have appeared recently in the technical papers.

1. *Alternative Systems of Transmission Units.*

(*a*) Mile of Standard Cable. In this system the transmission efficiency of a circuit is stated as being equivalent to that of x miles of standard cable. The standard cable is defined as an air-space paper-core cable with the following constants (per mile):—

$P_1 = 88$ ohms, $L = 0.001$ Henry, $G = 10^{-6}$mho., $C = 0.054\,\mu F$.

This is the recognised unit in Britain and until recently in America, except that the constants adopted in the two countries differ slightly. It is also used in the Dominions and several other countries.

(*b*) The "800-cycle mile." This unit has an attenuation equal to that of a mile of standard cable at a frequency of 800 cycles per sec. It has been used in America and Britain to fulfil the need for a unit which is independent of frequency and of a recognised magnitude. Non-reactive artificial cables calibrated in this unit have been in use for some time.

(*c*) The "Natural" Attenuation Constant β.

This system has been used until recently for all mathematical work in connection with telephone transmission. In Germany and some other countries it is also used for general engineering purposes.

(*d*) The "T.U." This unit has recently been introduced in America. In this system two points on a transmission line are stated to be 1 TU apart when the ratio of the power being transmitted through them is equal to $10^{0.1}$. It will be seen that the essential differences between this unit and "β" is that the TU is based on a Power ratio instead of on a current or voltage ratio and the logarithmic base 10 is used instead of the natural base e.

(*e*) The "Décie." This unit is one tenth the magnitude of the "natural" unit β and has been proposed as being of a more convenient size. It is not actually in use, but has been discussed at International meetings.

In order that the relative merits of these units may be compared the characteristics of an ideal unit will be examined and the merits of the various alternatives summarised with respect to their fulfilment of these requirements.

2. *Characteristics of an ideal unit.*

The unit should be:—

(*a*) Logarithmic in character.

(*b*) Independent of frequency.

(*c*) Convenient for use in theoretical investigations.

(*d*) Convenient in practical work.

(*e*) Of a suitable magnitude.

(*f*) Suitable for the expression of all types of transmission losses and gains. For example, losses due to apparatus in bridge, reflection and transformers, or gains due to repeaters.

(*g*) The unit should preferably convey a definite physical meaning.

(*h*) The transfer from existing systems should be as simple as possible.

(*i*) It should be possible to make up adjustable artificial cables calibrated in units.

3. *Compartive merits of the alternative units.*

Mile of Standard Cable (*M.S.C.*). This unit satisfactorily complies with conditions (*a*), (*e*), (*g*), and (*i*). With regard to the other conditions :—

(*b*) It is not independent of frequency.

(*c*) It cannot conveniently be used for theoretical calculations.

(*d*) Since the introduction of loaded cables and repeaters there has been considerable difficulty in applying the M.S.C. to practical work, due to the fact that it is not independent of frequency.

(*f*) Losses due to apparatus in bridge, etc., may be expressed in terms of M.S.C. and this method has led to satisfactory results in practical work. Further particulars as to the impedances and phase differences involved are necessary for a full theoretical statement of the case.

(*h*) The transfer would involve alteration of records and construction of standard cables in the case of countries where other systems are in use.

With reference to the construction of artificial cables (*i*), they are usually made containing resistance and capacity only. The error due to the omission of inductance and leakance is not appreciable when the cable is used for speech tests only. Inductance and leakance of the correct values can be added if the cables are required for A.C. tests.

The 800-*cycle mile*. This unit satisfactorily complies with conditions (*a*), (*b*), (*d*), (*e*) and (*i*). With regard to the other conditions :—

(*c*) It cannot be used conveniently in theoretical calculations.

(*f*) The remarks made in the case of the M.S.C. apply, except that the "800-cycle mile" is independent of frequency.

(g) The unit does not represent any actual type of cable.

(h) The transfer from existing systems would be fairly simple but it would involve alteration of records and standards.

The Attenuation Constant β. This system satisfactorily fulfils conditions (*a*), (*b*), (*c*) and (*i*). With regard to the other conditions:—

(*d*) The system presents no difficulties in its practical application to long uniform lines. In the case, however, of lines involving reflection losses some difficulty is experienced which is referred to under (*f*).

(*e*) The magnitude of the unit is somewhat large and it is generally necessary to employ two decimal places in expressing the attenuation length of normal telephone lines.

(*f*) Losses such as those mentioned can be investigated theoretically, but their accurate practical expression in terms of β is not simple. For the simple expression of such losses a power unit is more suitable.

(*g*) The unit does not represent any actual type of line.

(*h*) The transfer from existing systems would involve alteration of records and standards.

The "TU." This unit satisfactorily complies with conditions (*a*), (*b*), (*d*), (*e*), (*f*) and (*i*). With regard to the other conditions:—

(*c*) The adoption of base 10 for the logarithms involves the use of a factor to convert from the natural base. The theory of transmission has been built up from a consideration of the distribution of current and voltage along a transmission line and this, or its equivalent, is necessary for the full development of the theory.

(*g*) The unit does not represent any actual type of line.

(*h*) The transfer would be fairly simple but would involve alteration of records and standards.

The "Décie." This unit satisfactorily complies with conditions (*a*), (*b*), (*c*), (*e*) and (*i*). As regards the other conditions the same remarks apply as in the case of β.

To sum up, the mile of standard cable, although it has been of great value in the past, is no longer suitable for present requirements and is to be abandoned as a unit of transmission. The 800-cycle mile introduces an unnecessary factor in calculations and was only adopted as a temporary measure until a more suitable unit was authorised. It should be abandoned as soon as such a unit is decided upon.

The Décie was considered at International Conferences and the majority of nations represented preferred "β" on account of the confusion which might arise from the use of two methods of expressing attenuation.

At a recent international meeting in Paris the choice was reduced to that between " β " and "TU." The majority of nations represented preferred β and the matter was referred to the International Electro-Technical Committee. It is possible, however, that in the course of further deliberations, some compromise might be adopted, such as a " Power Unit " referred to the natural base of logarithms, e.

Apart from technical considerations, there is the question of uniformity of practice among different nations. America has apparently definitely adopted the "TU " and it would therefore be an advantage from this point of view if European nations adopted the same unit.

An unfortunate typographical error crept into Mr. Ragnar Holm's article on " The validity of Erlang's Trunk-Congestion Formula," which appeared in our January issue. At the top of page 320 in line 2, please read " is $= x$ for all . . . . " in place of " is = for all . . . . " We are sorry for the slip and hope no misconception has been caused by it.

We regret to announce the death of Mr. Herbert Watson Sullivan, who died, after an operation, on the 28th January. Mr. Sullivan commenced his electrical work with the Eastern Telegraph Company. Most telegraph men have acquaintance with the Sullivan Universal Galvanometer, which he produced in 1894, but not so many are aware of the large range of testing and cable apparatus which his firm has produced for our own and other administrations. Under his personal supervision the firm of H. W. Sullivan acquired a fine reputation for accurate and careful workmanship.

The following remarks made by the Mayor of Hampstead on the occasion of the opening of a 60-line P.A.B.X., on the 23rd February, may be of interest :—

" The new Automatic Telephone Exchange installed in this Town Hall, and which is linked with the Public Service is, I understand, the first to be installed by any of the Metropolitan Boroughs, and marks a further advance on the part of Hampstead in keeping their Administration up to date. Not only is every Official Department, and indeed every official apartment throughout the Municipality, in instant automatic communication with every other one, but it can also establish immediate communication with the Public Exchange Service.

Under the previous arrangement of manual working, such Departments as the Elect. Station, the Works Dept., the Central Library, etc., had independent exchange lines, so that an official at, say, the Town Hall wishing to speak to the Elect. Station, had to put his call through the operator at the Town Hall, who passed it through the Hampstead Exchange, who in turn passed it through the operator at the Elect. Station. This took anything from 30 to 50 seconds, or more, and each call cost 1¼d.

" In the Relay Automatic Installation, which has now been provided by the G.P.O. for this Corporation, the official dials the wanted person direct and is through to him in 3 seconds, whilst the call costs nothing.

" Under the old system, when the operator had left at 5 o'clock in the evening, the telephone service was no longer available, and this was a disadvantage when Committees were sitting late. With the new Exchange, however, the instant interdepartmental service is available all night as well as day, and connection to the Public Exchange Service is available *via* certain night lines which are connected by the operator before she leaves.

" The two points which should chiefly appeal to Municipal Authorities are that all interdepartmental calls on the Automatic System are connected in 3 seconds and that all such calls *cost nothing*, and secondly, telephone operators at outlying Departments can be dispensed with.

" The nature of a Municipal organisation renders it imperative that the various buildings should be scattered throughout the district, but by centralising the telephone service on a " Relay " Automatic Switchboard at the Town Hall, as Hampstead has done, and several other Corporations are proposing to do, judging by the enquiries we have had, the members of the various staffs are enabled to speak to one another just as quickly and just as cheaply as if they were all sitting in the same room.

" From the point of view of Municipal Administrations the advantages of automatic telephony are considerable, each department has the same facilities, and co-ordination is greatly intensified."

The Mayor then made the first official call and declared the Exhange open.

Messrs. W. T. Henley's Telegraph Works Company, Ltd., owing to the expiration of the lease, are removing their Head Office from Blomfield Street, London Wall, on March 18th, to 11, Holborn Viaduct, E.C.1. Their London warehouse which has for some years been situated at 18, New Union Street, E.C., will be also transferred to the new premises at the same time. The firm has been at Blomfield Street for 21 years and the lease expires on the 25th March. For several years the accommodation at Blomfield Street has been quite inadequate to the needs of their greatly increased staff, a large part of which has occupied offices in New Broad Street and in Finsbury Circus House, No. 10, Blomfield Street, in addition, of course, to our occupation of the whole of the building at 13/14, Blomfield Street. The warehouse was transferred to New Union Street 3 or 4 years ago in order to increase the office accommodation at Blomfield Street.

The new premises at Holborn Viaduct were formerly the "Holborn Viaduct Hotel." They have been rebuilt internally and decorated to form a commodious suite of modern offices and warehouse. There is sufficient accommodation in the new premises for all departments to be housed under one roof. They are situated at the eastern end of Holborn Viaduct.

Mr. W. R. Bailey, Superintending Engineer's Office, Glasgow, is willing to dispose of Volumes I. to XVI. of this Journal, bound and in good condition.

The Fox Film Co. are releasing at the end of April a film with the title "Daughters of the Night," which deals with the life of a telephone girl and contains many scenes of large and small exchanges, as well as operations by telephone engineers. A less intriguing title might have been chosen, we submit, but no doubt the company knows its public better than we do.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
Cwmbran New	Auto	66
Birkenhead New	Manual	3640
Manchester Central Extn..	,,	2100
Burndepts Ltd. Extn. ...	P.A.B.X.	10
Charlesworths Ltd. ...	,,	80
Duckworths Ltd.	,,	30
Great Western Railway ...	,,	50
Hampstead Council ...	,,	60
Higginsons Ltd. Extn. ...	,,	5
London Elec. Wire ...	,,	40
Lowthian Drake	,,	40
Philips, J. & N.	,,	100
Spillers Milling Co. ...	,,	100
Triumph Cycle Co. ...	,,	70

Orders have been placed for the following New Exchanges :—

Exchange.	Type.	No. of Lines.
Burnley	Auto	1650
Edinboro' Central... ...	,,	8720
Morriston	,,	320
Southwick	,,	110
Battersea	Manual	5500
Coatbridge	,,	600
Shipley	,,	1080
Walworth	,,	3700
Benton's Ltd.	P.A.B.X.	40
Booths Ltd.	,,	40
Bury Co.op.	,,	50
Cardiff Union	,,	50
Du Cross Ltd.	,,	50
Dunlops Ltd.	,,	50
Gardners Ltd.	,,	60
Hayes Ltd.	,,	40
Morris Motors	,,	130
Nairns Ltd.	,,	80
Robinson's Ltd. (3) ...	,,	70
Scottish Autos	,,	50
Shell Mex Ltd.	,,	30

Orders have been placed for extensions to existing equipments as follows :—

Exchange.	Type.	No. of Lines.
Chiswick	Manual	1500
Eastbourne	,,	1120
Guildford	,,	540
Huddersfield	,,	720
Ramsgate	,,	380
St. Annes	,,	540
Speedwell	,,	2100
Toll M.F.	,,	—
Uxbridge	,,	220
Woking	,,	300
Burndepts Ltd.	P.A.B.X.	10
Higginsons Ltd.	,,	5
Willis Faber Ltd.... ...	,,	10

Fenny Stratford Telephone Repeater Station (permanent) has been completed by the contractors. We hope to be able to describe the lay-out of one of the new repeater stations in an early issue.

*The Engineer-in-Chief had a crowded audience at the Institution of Electrical Engineers on Thursday, the 12th March, when he read his paper on "The Post Office and Automatic Telephones." In printed form, the paper runs to 42 pages of the Journal of the Institution and constitutes a complete history of the development and progress of automatic telephony in this country.

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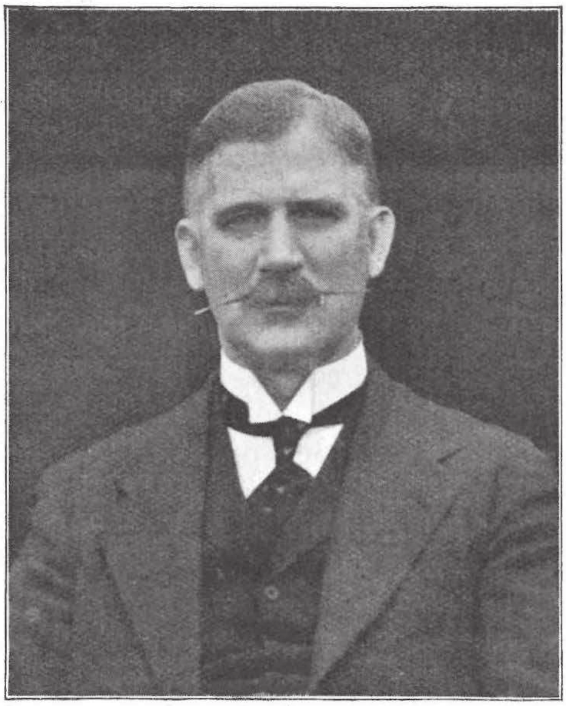
* A limited number of copies of the paper is being obtained for Journal subscribers who do not obtain it from the I.E.E. in the usual manner.

MR. E. H. SHAUGHNESSY.

We have pleasure in announcing the appointment of Mr. E. H. Shaughnessy, O.B.E., to the newly created post of Assistant Engineer-in-Chief in charge of Wireless Services.

Edward H. Shaughnessy, O.B.E., M.I.E.E., M.I.R.E., needs no introduction to the readers of this Journal, as he has been for several years a member of the Board of Editors, over which body he has presided for the past three years.



Mr. E. H. Shaughnessy, the new Assistant Engineer-in-Chief.

He was born in 1871 and entered the Post Office in 1887. After several years of service in the C.T.O. he joined the Engineering Department in 1896 as a Sub-engineer. He passed rapidly through the ranks of 2nd Class Engineer (1898), 1st Class Engineer (1901), 2nd Class Technical Officer (1903), doing service in the Experimental, Test, Telegraph and Cable Sections of the Engineer-in-Chief's Office. He also served as third Cable Engineer on board the S.S. "Faraday" during the laying of a new submarine cable across the Gulf of Mexico from Galveston to Coatzacoalcas, and in the repair of deep sea cables.

In 1908 he was transferred as Assistant Superintending Engineer to the Eastern District, and early in 1913 he returned to

Headquarters as a Staff Engineer to take charge of the Wireless Section of the Engineer-in-Chief's Office. He entered this section at a very important period in its history. The Coast Stations for dealing with Ship and Shore traffic had been taken over from Marconi's Wireless Telegraph Company in 1909 and a complete engineering reorganisation was being undertaken. Negotiations were also proceeding with Marconi's Wireless Telegraph Company for the erection of the stations which were to form the Imperial Wireless Chain. This contract was duly entered into in 1913, but was cancelled on account of the War in 1915, the cancellation resulting in the arbitration case in which the Company were awarded £590,000 damages for Breach of Contract, their claim being for some £7,000,000. Mr. Shaughnessy acted as expert technical witness for the Crown in this case. He has also acted as technical adviser in several patent litigation cases.

At the commencement of the War Mr. Shaughnessy was solely responsible for the organisation for the detection of unauthorised Wireless Transmissions, the menace of which loomed so large in the columns of the Press and in the minds of the Public in those early days. In spite of the many scares investigated no case of a serious nature came to light. Later, he was responsible for the control of a system of Direction Finding Stations for Home Defence, which performed the invaluable service of tracing the Zeppelins across the North Sea on their bombing expeditions. It was not until after these stations were in operation that the first of the Zeppelins was brought down in this country, and it cannot be doubted that the system of direction finding stations was one of the principal agencies which caused the ultimate abandonment of this nefarious campaign.

For these services Mr. Shaughnessy was awarded the honour of being made an officer of the Order of the British Empire.

The close of the War found the Wireless Section in possession of two sites for High-power Wireless Stations, *i.e.*, at Leafield and Cairo, with mast systems erected or in course of erection, and in spite of shortness of staff, Mr. Shaughnessy, with characteristic energy, set about the equipment of these stations. At this period the high frequency alternator had hardly passed the experimental stage, thermionic valves had not been developed for greater ratings than about half a kilowatt, and the Marconi timed-spark system, which had been developed during the War and which was an advance on the synchronous spark system proposed for the original scheme, was to all intents obsolescent. The Elwell Poulsen Arc System was, however, a good commercial proposition and Mr. Shaughnessy recommended its adoption. Although much criticism was levelled against this decision, events have abundantly justified its wisdom.

In 1919 a Committee, under the Chairmanship of Sir Henry Norman, was appointed by the Government to conduct an enquiry into Imperial Wireless Communications and, as a result of their recommendations, a Wireless Telegraphy Commission, under the Chairmanship of the Rt. Hon. Viscount Milner, with three technical members, was appointed by the Cabinet in 1920. Mr. Shaughnessy has been a member of this Commission since its inception. Although the original recommendations of the Norman Committee could not be brought to fruition owing to the non-participation of the Colonies in the scheme, the erection of a high power station in this country was decided upon and this is now in course of erection at Rugby.

In 1921, Mr. Shaughnessy acted as a British delegate at the Inter-Allied Technical Conference on Wireless Telegraphy which was held in Paris and lasted six weeks.

Mr. Shaughnessy is a man of very many activities. He will be well remembered by a large number of his old students as a lecturer in Electrical Engineering, Telegraphy and Telephony at various London Technical Institutes. At the present time he is the Examiner in Telegraphy for the City and Guilds of London Technical Institute, a member of the Radio Research Board, of several committees and panels of the British Engineering Standards Association, and of the Royal Society's National Committee of the International Research Council. In 1922 he was selected by the Royal Society to act as one of their delegates at the Second Assembly of the International Research Council, held at Brussels, for the Union Internationale de Radiotelegraphie Scientifique. For the past two years he has occupied with distinction the Chair of the Wireless Section of the Institution of Electrical Engineers, and last year he was elected unopposed as a member of the Council of that Institution. He is also a Vice-President of the Radio Society of Great Britain and the Schools Radio Society.

Mr. Shaughnessy hides beneath an apparently casual manner an eye for detail, whether it be for specification, drawing, or minute, which gives to his staff the assurance that no error of importance is likely to escape his notice. The sphere of Radio patents he has made particularly his own, and here his wonderful grasp of the situation, combined with a remarkable memory for its details, has won him general acknowledgement as an expert.

No one who has come into contact with the Wireless Section of the Engineer-in-Chief's Office can have failed to have noticed the regard in which Mr. Shaughnessy is held by his staff, and how he has impressed his spirit of cheerful optimism upon them.

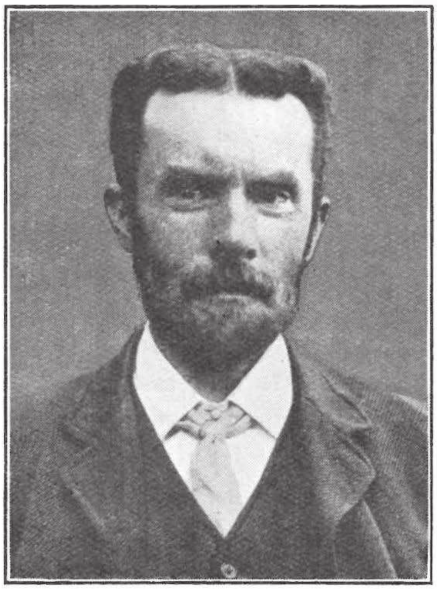
We are sure Mr. Shaughnessy has the best wishes of his many friends, both inside and outside the service, on the occasion of his promotion.

OLIVER HEAVISIDE, F.R.S.

From *The Electrician,* February 13th, 1925.

It is with great regret that we have to record the death of Mr. Oliver Heaviside, F.R.S., which occurred at Torquay, on February 4th, at the age of 75.

Heaviside's death marks the passing of one who had a great influence in increasing our knowledge of the scientific principles upon which much of the recent progress in telegraphy, telephony and radio communication has been based, for he established a connection between Maxwell's electro-magnetic theory and " weak current " practice whose full possibilities we are only now beginning to realise. He established this connection, however, in a way which not only shocked pure mathematicians of the rigid school, but brought upon him criticisms from the practical men whom he desired to help. These two results at first made his recognition difficult, but it has now been recognised for some years that what he did was of fundamental importance. We may, therefore, be allowed some self-gratification in recalling that publicity was given to his work in the columns of *The Electrician*. A large part of his well-known work on the " Electro-Magnetic Theory," which is now published by Ernest Benn, Ltd., first appeared in the form of articles in our columns, and though its publication raised a good deal of criticism on account of its being intelligible



OLIVER HEAVISIDE, F.R.S.

to only a small proportion of our readers, those responsible for the conduct of the journal in those days have been amply justified by events.

It is difficult to write a suitable obituary notice of Heaviside because the manner in which he lived during many years of his life, and his great age have made it impossible to obtain any details of his early life and practical work. We do know, however, that he was born in London on May 13th, 1850, and was for a few years in the employment of the Great Northern Telegraph Co., at Newcastle-on-Tyne. At the early age of twenty-four, after a short time spent in London, he retired to Torquay where practically all of his subsequent work was done. He lived practically the life of a hermit, seeing few people, but corresponding with one or two with whom he had ideas in common, notably, Sir Oliver Lodge and Dr. G. F. C. Searle, of the University of Cambridge.

The result of this existence, which he chose for himself and which probably suited him, was a legend that has grown up round him and which probably only his death will disperse. The important thing about Heaviside, however, was not his life but his work. What this work was and the results that have been obtained from it are fully elucidated by Sir Oliver Lodge on p. 174 of this issue. Although Heaviside took up the attitude that what he had done had not received due recognition, there was, at any rate in recent years, no real basis for this opinion. He was elected a Fellow of the Royal Society in 1891, became the first Faraday Medallist of the Institution of Electrical Engineers in 1922 (having been elected an honorary member in 1908) and received the recognition of Honorary Membership from many learned foreign and scientific societies.

His earlier papers were published by Macmillan in two volumes under the heading of " Electrical Papers," in 1892, and his principal work, " The Electro-Magnetic Theory," was published by *The Electrician* Printing and Publishing Co., in three volumes, in 1893, 1899 and 1912, respectively. It was reprinted in 1922 by Benn Bros., Ltd., and it is interesting, as an indication of the value that is placed upon the arguments and results given in it, that a further edition is now in preparation by Ernest Benn, Ltd.

The funeral took place on Friday, February 6th, at Paignton Cemetery, in the family grave in which his father and mother are also buried.

The following were present: Mr. B. B. Heaviside, Mr. C. Heaviside, Mr. and Mrs. F. Heaviside, Miss Heaviside, Mr. and Mrs. Williams, nephews and nieces, and Mr. R. H. Tree, who represented the Council of the Institution of Electrical Engineers. The American Telephone Co. and the Western Electric Co. were also represented.

OLIVER HEAVISIDE, F.R.S.

AN APPRECIATION: THE PERSONAL EQUATION: THE WORK OF A GENIUS ELUCIDATED.

By Sir Oliver Lodge, F.R.S.

From *The Electrician,* February 13th, 1925.

Occasionally a remarkable genius arises, we know not how nor whence. Such an one runs the risk of being misunderstood and neglected in his lifetime; partly perhaps because he has not gone through the ordinary processes of education, and has therefore not attracted the attention of his contemporaries in the regular way, and partly because his insight may be of an unorthodox and exceptional type, and his utterances personal and peculiar in style. He is also apt to be more or less in advance of his time, so that it is sometimes left to posterity to discover the brilliance and notable character of his achievement. Such an one was Waterston, who evolved the kinetic theory of gases years before the scientific world was ready to receive it; with the result that his communication to the Royal Society on the subject was turned down by the referees; and we are now told that among Waterston's papers will be found other striking anticipations of the course of scientific progress, though they have not as yet been made public.

A Genius of Exceptional Ability.

Such an one again was Oliver Heaviside, a mathematical genius of exceptional ability, who flooded the columns of *The Electrician* with remarkable but ill-understood Papers, the value of which was, however, recognised long before his death (partly by Kelvin, partly by Fitzgerald, Dr. G. F. C. Searle, and others), but which for all practical purposes had been turned down by the telegraphic authorities of his time, and regarded as nonsense by no less a personality than Sir William Henry Preece, that genial orator, for many years engineer-in-chief to the Telegraphic Department of the British Post Office. Indeed I was told that a practical Paper by his brother, A. W. Heaviside, of Newcastle-on-Tyne, was rejected by the Society of Telegraph Engineers, because it embodied in more practical form the results of his brother's mathematical researches. There is no doubt that Oliver Heaviside felt this neglect and contumely very keenly, and he gave expression to it in humorous and sarcastic fashion on many occasions.

All this is now ancient history, but reference to it cannot properly be omitted, for it loomed large in Heaviside's mind and saturates many of his lighter Papers. Besides, when serious mistakes are made, it is only just that for a time they should be remembered. Recognition, though tardy, came at length—perhaps too late to be altogether consoling. The Royal Society made him a Fellow; the Institution of Electrical Engineers awarded him their most distinguished medal; and their President took the trouble to convey it personally to him at his solitary home in the depths of the country.

Part of the difficulty of recognising his achievements lay no doubt in his own personality; he was of very retiring disposition with no social gifts. He lived alone, in what appeared to be a state of considerable poverty, cooking his own food, waiting on himself, and suffering from indifferent health. He was visited from time to time by occasional admirers of his genius, in his dismal lodgings at Kentish Town. But as soon as he began to be recognised he fled to Devonshire, and thence emerged no more; never, so far as I know, attending the Royal Society, nor the Electrical Engineers, nor coming to hear the congratulations which might—late in life—have been showered on him; and living to the end the life of a recluse.

He was a voluminous correspondent, however, and both FitzGerald and myself received innumerable letters from his pen. Dr. Searle also must have received many, and probably continued to know him personally better than anyone else. He it is who would be able to tell us more about Heaviside's life and education. How he acquired his mathematical knowledge I do not know; I hope that Dr. Searle does, and will tell us. But the outcome of his singular mind is embodied in several volumes of "Electrical Papers" (published by Macmillan in 1892) and other volumes on "Electromagnetic Theory" (published by *The Electrician* Printing and Publishing Company in 1893, 1899 and 1912). A recent reproduction of these last, in three volumes, with the same title, has been recently issued by Benn Brothers (now Ernest Benn, Ltd.).

The fact that these early Papers were accepted (I presume paid for) and published by *The Electrician*, for many years, redounds greatly to the credit of that organ; for there could have been but few of its readers who really understood them: by the majority they must have been regarded with more or less awe, perhaps with some suspicion, but with certainly less than adequate attention.

Heaviside had, however, a peculiar vein of humour, and sometimes his writings amused, even though they did not edify. He had a wonderful instinct for grappling with the difficulties of a subject and giving it symbolic expression. Probably no one in his time had an equal grasp of the present and future outcome of Maxwell's theory. He expressed the generation of electric waves in his own style: he treated of the motion of electric charges at different velocities, including those which equalled or even hypothetically surpassed the velocity of light. Everything relating to electrical induction, and the energy of electric currents, and the forces and fluxes of energy in the electromagnetic field, the self-induction of wires and the generation of waves, was elaborately worked out in these early Papers. He invented a special system of vectorial algebra with which to deal with them. His mathematics often aroused the admiration of John Perry and other competent judges. And the three volumes on " Electromagnetic Theory " may be taken as a summary of his matured views on these subjects.

It seems probable that workers on the science of the ether will make more use of his methods and results than they have at present done; though the peculiarity of his modes of expression rather alienated, for a time, and perhaps even to this day, the majority of Cambridge mathematicians; for, though there is much originality, there is little orthodoxy in his manner of presentation.

Cable Theory.

The chief subject on which his fame rests at present, the subject also which at the time aroused rather bitter controversy, was his development of the theory of cable signalling. This theory was (as all the world knows) begun by Kelvin: and it may be truly said that Kelvin's theory of the propagation of pulses along cables, taking into full consideration their resistance and their capacity, rendered the Atlantic cable of 1865 and 1866 possible: and it may be said that it was neglect of that theory which slaughtered the first cable in 1858. Kelvin's theory, however, was incomplete: it proceeded on the analogy of conduction of heat: it applied Fourier's analysis of heat conduction to the electrical case: and the results, though most helpful, indeed invaluable, were by no means the last word on the subject. Self-induction, though doubtless partially understood by Kelvin (he called it electrodynamic capacity), was not introduced into his theory, it was probably considered a negligible factor for a long straight wire. Heaviside recast and remodelled the theory in the most general form: he invented the terms " inductance " and " reluctance," " reactance," " permeance," " permittance," and the like, on the lines of the term " resistance "; and some of these terms have come to stay. He showed that the propagation of signals along wires was in all essential respects identical with the laws of propagation of electric waves in free space. So that when I had the pleasure of detecting electric waves along wires, in or about 1888, at the same time as Hertz detected them in free space, Heaviside hailed both observations as practically one and the same—though there is no doubt that Hertz's investigations eclipsed mine altogether, in thoroughness, as well as in practical results.

The Theory of Wave Transmission.

The theory of the transmission of waves along free aerial wires is simple enough. The equations are much the same as for waves anywhere else: they are given in my "Philosophical Magazine" Paper for August, 1888, near the end of a disquisition on lightning conductors. But Heaviside did not stop at waves along aerial wires: he applied the theory to impulses along cables, where the combination of capacity and resistance exercised its deleterious effect, and constituted the great difficulty in efficient signalling. He showed that by taking self-induction into account, the results could be much more accurately expressed, and further, that self-induction was not the hindrance or bugbear which Sir William Preece thought it was, but that it was the most essential help. And, indeed, without inductance it is difficult to see now how any transmission theory could be satisfactory. Heat has no rate of propagation: it is merely diffusion; and Kelvin's theory of cable signalling was entirely on diffusion lines. The waves, as it were, soaked through, and the time of arrival was quite indefinite; it depended merely on how sensitive the receiving instrument could be. If you had to signal by heat, along a rod of copper, to a thermometer at one end, by applying to the other end, first a flame and then a block of ice, alternately, so that the distant thermometer could experience pulses of temperature and respond to the signals (which in imagination might be dots and dashes), no rate of propagation could be specified. An infinitely sensitive thermometer would feel the influence at once; any practicable thermometer would feel it after considerable delay. But the delay could be reduced by making the thermometer still more sensitive: and that is what Kelvin did; his mirror galvanometer and syphon-recorder were instruments far more sensitive than any of their predecessors: and accordingly the very beginnings of diffusion were felt, and could be stopped, before they had accumulated, by an opposition pulse. That was, and to some extent still is, the system of cable signalling.

The Effect of Inductance.

But when inductance is taken into account it is seen that there is a definite velocity involved—viz., the velocity of light. No instrument could respond instantaneously, even if infinitely sensitive. True waves are passing along the cable, though greatly modified by the distortional effect of diffusion, which has the effect of transmitting waves at different paces, and smoothing out sharp signals; after the same sort of fashion as a coach spring smooths out the bumps and irregularities of a road. Such smoothing out is to some extent tolerable, when dots and dashes, and especially when right and left deflections, are used. A dash is not suitable for transmission, it lasts too long; but right and left deflections, that is positive and negative signals, may be quite brief—the briefer the better, for then there is nothing to accumulate; the positive pulse is curbed by the immediately following negative pulse. All this was applied by Fleeming Jenkin and other telegraphic experts; but no one contemplated the possibility of telephonic speech through a long cable, even after the telephone had been invented. The smoothing out of consonants would reduce them to nonsense; and on Lord Kelvin's theory speech would be unintelligible and impossible of transmission on any cable longer than, say, that across the Irish Sea.

But Heaviside's theory modified all that: he showed that the effect or tendency of inductance was to add momentum to the signals, to give them a real speed, to wipe out much of the deleterious effect of capacity, to transmit waves of all lengths at the same speed; so that if only sufficient inductance could be employed, signals could be transmitted even along a cable of Atlantic length without distortion. He gave in fact the theory of the distortionless cable.

He showed also that a certain amount of leakage, lateral escape of electricity, would improve the signals: it would weaken it, of course, but the attenuation might be more than compensated by the absence of distortion.

The Influence of the Magnetic Field.

Put into words, by way of exposition of one aspect of the theory, one may say that for the transmission of true waves—not diffusion waves like heat, but waves like light, waves such as exist in free ether, and approximately along an aerial line—the electric and the magnetic energies are required to be equal. If one overpowers the other we have distortion, varying rates of transmission, or no rate of transmission at all, nothing but diffusion if the overpowering is excessive. In Kelvin's theory it was excessive, because there the inductance was considered zero, that is to say, the magnetic field was neglected; the electric field alone was taken into account. Heaviside pointed out that the magnetic field was really doing the work, though greatly overpowered by the electric, especially in cables of large capacity. By adding self-inductance, magnetic energy could be increased and made more equal to the electric energy; by leakage the overplus of electric energy could be still further reduced, though less economically. If the two energies could be made quite equal we should have true distortionless waves, with every feature of the signal reproduced at the far end, subject to nothing but attenuation.

Such a state of things can only be approximated to in practice. Silvanus Thompson advocated the construction of cables with added inductances, so as to carry out into practice Heaviside's views; and everyone knows that Prof. Pupin, in America, succeeded in influencing capitalists to make such cables according to his design; and they were found to have just the properties predicted for them. Moreover, in America successful enterprise has gone further. They really have long-distance telephony there (they say that we have not got any long distances, and therefore have not attended to it so fully); they apply extra inductance to their land lines. And in that way I am told that the General Electric Co. (or perhaps it is the Western Electric C., I am not sure) by applying extra inductance at regular intervals along their extensive continental lines. find it possible to transmit clear and distinct telephone speech from New York to California, and beyond.

Practical Results of Heaviside's Theory.

I am now trespassing on subjects concerning which practical experts are more fully informed than myself. But I have said enough to indicate that these interesting and extensive developments (of which we have not as yet by any means heard the last) owe their origin and inception to the genius and perspicacity of the subject of this memoir. That he failed to derive any pecuniary benefit (at least as far as I know) is to be lamented; but under the present system of scientific recognition (or non-recognition) it was probably inevitable. It was not an easy matter to help Heaviside pecuniarily: I believe that FitzGerald, and probably others, tried once or twice; but he had a pride which discouraged such attempts. A Government pension he was ultimately prevailed on to accept, provided it was so put as to recognise his work for Science, so as to remove it from anything of an eleemosynary character.

He has left his name on the atmosphere in the form of a "Heaviside layer," which is considered responsible for the transmission of electric waves to the Antipodes round the curvature of the earth.

Another little excursion of his is noted in the "Philosophical Magazine" for January, 1925, where a Japanese Professor describes a method for making an electret by electrising a dielectric, on the analogy of magnetising a permanent magnet; and finds that his idea was anticipated by Oliver Heaviside in "Electrical Papers," Vol. i., §xii., under the title "Electrisation, Natural Electret."

Heaviside was fond of tracing magnetic analogies to electric phenomena: hence his name "reluctance" for the magnetic analogue to resistance. He even introduced a pseudo-magnetic coefficient in some equations, so as to make them more symmetrical and therefore more pleasing to mathematicians. His theory of the distortionless cable is very complete and beautiful; he knew how to avoid reflections at distant ends and how to design a cable of any desired properties. His brother worked practically, and accumulated data, in the same direction; but he was suppressed.

I do not think the man was unhappy; though at one time he was rather embittered by the misunderstanding and hostility of those in authority—an attitude which a genial man like Sir William Preece would have been the first to lament had he been better informed. Heaviside lived an independent, self-contained life: and no doubt his insight into Nature (whether recognised by his contemporaries or not) must have given him moments of sincere pleasure. The least we can do now is to recognise his genius, and wish that it had been earlier recognised and more widely known.

THE VOCATION OF THE ELECTRICAL ENGINEER.

By THOMAS BOYES JOHNSON, Member,
Superintending Engineer, North Midland Section.

Extract from the Chairman's Address, I.E.E. North Midland Centre.

(*Address delivered at Leeds, 11th November, 1924. The extract is taken from the Journal of the Proceedings of the Institution*).

No one can read the reports of the proceedings* at the Commemoration Meetings of this Institution held in February, 1922, without being struck by the enormous development of engineering during the last 50 years. Dealing with electrical engineering, it seems incredible that at the time of the birth of many of us electric lighting was practically unknown, the telephone had not been invented, electric trams and railways had not been thought of, whilst wireless telegraphy and telephony—which have now attained such universal prominence—were not even dreamt of. The dynamo entered the area of commercial use less than 50 years ago, and it still seems almost miraculous that the turning of a mass of iron enclosed in wire in an electromagnetic field should give us lighting, heating, traction and power in such various ways and to such an enormous extent as we have to-day.

There is no reason to think that there will be any slackening in the field of discovery or in that of practical application. As Prof. Howe remarked at the meeting of the British Association in August last:† "We can look forward with confidence to an ever-increasing application of electricity to the utilization and distribution of the natural source of energy for the benefit of mankind.''

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* *Journal I.E.E.*, 3922, vol. 60, p. 377.

† *Electrieal Review*, 1924, vol. 95, p. 239.

Telephony.

It seems almost incredible that the first telephone exchange was established so late as 1878, while to-day there are well over 20 million telephone exchange stations in various countries, nearly 1¼ millions being in Great Britain. The first multiple exchange was established 10 years later, and by means of these multiple boards one operator can have access to 10,000 lines. It is physically impossible for one operator to obtain access to a greater number. With the development of the automatic system, however, this limitation disappeared. The first automatic exchange in this country was opened at Epsom in May, 1912, and several others were completed in 1915 and 1916. The first large city to be provided with an automatic exchange was our own city of Leeds, where, in spite of serious difficulties owing to the war, a 5-figure exchange constructed by the Automatic Telephone Manufacturing Co. was opened in May, 1918. This was the largest automatic exchange in Europe, and the largest in the world to be transferred from the manual to the automatic system. It is still the only 5-figure exchange in Great Britain, but a similar one is being constructed in Sheffield, other automatic exchanges are being provided in various towns, and the conversion of the London system to automatic working has been commenced. A 4-figure exchange at Grimsby constructed by Messrs. Siemens was opened in September, 1918, and proved equally satisfactory. Another 4-figure exchange has just been opened at York, and the conversion of the Leeds suburban exchanges to automatic working is proceeding steadily. A 4-figure exchange at Harrogate has been commenced, one at Halifax will be started as soon as the building is ready, and others will follow at Wakefield, Keighley and other places within the area of the North Midland Centre. The Hull Corporation have also opened two automatic suburban exchanges. We are glad to know that the system in Leeds has proved the advantages of automatic telephone working, and that the Post Office authorities are now definitely committed to the establishment of automatic working as the standard method for large exchanges.

Another important development in telephony has been in the distance over which speech can satisfactorily be transmitted. In Graham Bell's first business circular it was stated that telephones could be furnished for the transmission of speech through instruments not more than 20 miles apart. With the improvement of lines and apparatus the distance was largely increased, but was still limited. Continued attempts were made to devise a telephonic relay to repeat telephone currents in the same way as the well-known telegraphic relay, but all these proved unsatisfactory. With the invention of the thermionic valve or repeater, however, the difficulty disappeared, and there is now practically no limit to the distances over which speech can be transmitted. Speech is already carried from East to West of the American continent, and there is no technical reason why it should not be carried equally well between the extremes of North and South America.

Improvements in the condition of the lines used for telephone working have been remarkable. For many years it was necessary to use aerial wires, owing to the limited distance possible with gutta-percha-covered or rubber-covered conductors. Air-space cables increased the distance considerably, and the invention of the loading coil straightway enabled the distance to be increased about threefold. In 1913 the first balanced cable for both telegraph and telephone wires in this country was laid between Leeds and Hull, and proved so successful that the laying of such cables for long-distance telephony became the standard practice. This balancing enables thermionic repeaters to be used, and telephonic communication by means of balanced cables, loading coils and thermionic repeaters can be carried on from one end of the country to the other.

International Telephony.

It will be remembered that Mr. Gill during his presidency of the Institution devoted great attention to the development of international telephony, and the development of this phase of telephony will undoubtedly occupy a prominent position in future. Here, again, the invention of the thermionic valve opened up a new era. By its means the British military authorities were enabled to have telephonic communication between London and the Expeditionary Force Headquarters in France. The Germans with the great advantage of land frontier had circuits from Berlin to the Army Headquarters in Northern France and Russia, and also right across Austria and the Balkans to Constantinople. Owing to its geographical position, as well as for other reasons, Germany is bound to occupy a large place in any scheme of European intercommunication. At the international conference held in Paris last year, at which Belgium, England, France, Italy, Spain and Switzerland were represented, much work was done in getting unanimous approval to many important technical proposals which were officially confirmed by the Governments of those countries, and further progress was made at a record conference in Paris in April last when no fewer than 21 European countries were represented. It is much to be hoped that Mr. Gill's plan of an international board for constructing, maintaining and operating long-distance circuits will be adopted. The influence of such an association and of international telephony would extend far beyond the boundaries of telephone working, and be of great service in creating and maintaining good feeling between the peoples of different countries, thus removing national misunderstanding, inspiring confidence and removing friction.

The Vocation of the Engineer.

If the electrical engineer has so much influence over the lives of fellow citizens and the conditions under which they live and work, it follows that whether employed by the State, a municipality or a limited company, he is in the best and most complete sense of the term a public servant, and he should realize the obligations which this places upon him. The education and training of the engineer are of great importance and have been dealt with in various addresses to the Institution. The pay of the engineer is also of importance, and the Institution should, without undue interference in wages questions, use its influence to raise the general standard of remuneration of engineering officers and men. In this connection reference is gratefully made to the letter sent by the presidents of the professional and technical institutions to the Prime Minister in February last, in which the greater recognition of scientific and technical men in the Government service was urged. It is wrong, for instance, that engineering workmen of long experience and training, and of great skill, should be receiving less wages than unskilled labourers in some occupations.

Of greater importance is the character of the engineer and the spirit which animates him. Realizing that the public depends upon him to so great an extent, the engineer will look upon his work not merely as an occupation by which he can earn a certain amount of money, but as a vocation. The public is entitled to the best service he can give, and a high ethical conception must be put on his duties.

There is one way, in particular, in which the electrical engineer can be of very great service in an important direction. Writers and speakers generally refer to capital and labour as if these were the only two classes affected in industrial matters, whereas the great bulk of the members of the Institution do not come within either of these categories, but are supervisors, etc. The ownership of factories in the North of England has changed in such a way as to alter largely the character of local life: whereas formerly the great productive concerns were owned and conducted by strong, shrewd men who had climbed out of lower ranks, their descendants have largely sold out to company promoters. Many men who still continue to be directors have mostly gone to reside at a distance, and their interest in the place of their origin, and in the community from whom they have derived their ample means, is ended, except for the limited duties of the board-room. With the decrease of private ownership which goes on at an increasing rate year by year, the old relations between the employer and his workmen are practically dead, with the result that there is a large amount of misunderstanding, distrust and fear between them. The engineer, whatever his supervising grade may be, can do a great deal towards filling the gap. He can represent the requirements of the employers to the men in a reasonable light, instead of simply issuing orders, and can receive suggestions or, if necessary, remonstrances, from the workmen, and represent them to the employers or directors. Many of the most serious industrial troubles of recent years have undoubtedly been due to misunderstanding and suspicion, and the engineer who shows himself worthy of trust by both parties, and loyal both to those above him and those below him, can exercise a very valuable influence in minimizing trouble. Engineers stand between capital and labour, and also between the public and its safety, and by their education, training, and sympathy with all classes seem specially competent to work out a solution of the industrial problem.

The engineer must look upon himself as a trustee and cultivate a high sense of the importance of his duty—which is not a question of self-importance—to his superiors, his subordinates, and the public. Employees must not be treated as machines or " hands " but as brother men engaged in improving the conditions of life and furthering the progress of mankind. There must be a spirit of real comradeship, which will have a high spiritual value and help to inspire the spirit of service in others. As has been well said, " The greatest service a man can do is to carry out his daily work in a spirit of service to God and man."

LONDON DISTRICT NOTES.

MILEAGE STATISTICS.

DURING the three months ended 31st December, 1924, the following changes have occurred:—

Telegraphs.—Nett increases in open wire and underground of 27 miles and 100 miles respectively.

Telephone (Exchange).—Nett decreases in open wire and aerial cable of 229 miles and 969 miles respectively and a nett increase of 19,070 miles in underground.

Telephone (Trunks).—Nett increases of 100 miles and 1,720 miles in open wire and underground respectively.

Pole Line.—Nett increase of 78 miles, bringing the total to date to 4,984 miles.

Pipe Line.—Nett increase of 149 miles, the total to date being 5,757 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	23,871
Telephone (Exchange)	1,556,197
Telephone (Trunks)	51,652
Spares	49,474

EXTERNAL CONSTRUCTION.

DURING the quarter ended December 26th, 1924, 10,278 exchange lines, 6,183 internal extensions and 1,105 external extensions were provided. In the same period 4,175 exchange lines, 2,740 internal extensions and 506 external extensions were recovered, making nett increases of 6,103 exchange lines, 3,443 internal extensions and 599 external extensions.

INTERNAL CONSTRUCTION.

New Exchanges.—A new C.B. Exchange of No. 1 type, to which the name of Franklin has been given, was opened for service on February 5th. The Exchange is located within the Victoria Exchange building and is equipped for 1,000 lines.

New Manual Exchanges are in course of construction at New Malden, Albert Docks, Palmers Green, Mill Hill, Tilbury, Sloane and Enfield. The Exchanges at New Malden and Sloane are being constructed by the Department's staff.

The installation of the Holborn Mechanical Tandem Exchange and the Holborn Automatic Exchange is proceeding. It is anticipated that the installation of the Bishopsgate Automatic Exchange will be started in the near future.

Extensions of Exchange Equipment.—A considerable amount of work of this nature is in progress and it has been necessary to augment the staff to meet the demands. Most of the Exchanges in the District are affected.

P.A.B.X.'s.—Private Automatic Branch Exchanges are being installed by Messrs. Siemens Brothers for the Port of London Authority at the various Docks, and for the Prudential Assurance Company. These are the first P.A.B.X.'s of Siemens type to be constructed in the District.

TELEGRAPHS.

Intercommunication Switch.—The first of the smaller concentrators, intended to replace the Intercommunication Switch, has now been installed and is working. A second portion of the old I.C.S. has been dismantled, amid the regrets of many lady operators who have worked on it from the first. They are asking for souvenirs in the form of scraps of the ornamental woodwork; but they agree that the new arrangements are more favourable from an operating standpoint.

The Central Telegraph Office is in the throes of building operations from the foundations upwards. Much shifting of engineering plant is involved, including pneumatic carrier-tubes, pressure and vacuum mains, and some useful clearances are being effected. For example, wrought iron pipes, originally containing G.P. wires, derelict for a quarter of a century, are being recovered, and those which are straight and in good condition will be re-issued.

THE NEW RADIO ROOM.

A Concentrator has recently been installed on the second floor at the C.T.O. for the purpose of receiving and transmitting wireless messages, audible by telephone and loud speaker and on tape by means of Machine Telegraphs. The lines are terminated on Jacks. Telephones and Telegraph Sets are terminated on Cords and Plugs and all wires are connected *via* a small I.D.F. by the side of the Concentrator, giving facilities for re-arrangement of circuits to meet traffic requirements. This Concentrator will operate in conjunction with a smaller one which has been installed in the Wireless hut on the roof of the C.T.O. In the case of the latter Concentrator, both lines and apparatus terminate on Jacks and are connected by looping cords. With a view to avoid interference from other circuits in the building, and having in mind the removal of the Wireless hut to a more suitable locality necessitated by local conditions, special cables have been installed to the C.T.O. Test Room, and connected by means of Jumpers, etc., to the Concentrator on the roof. All rectifying is carried out in the Wireless hut and signals are passed down to the new Wireless Receiving Room; the speed determines whether the message shall be received by Machine Telegraph or by Telephone. In the case of telegraphic reception, the signals are received on a suitable relay, the telegraph apparatus being in a local circuit.

MR. E. H. FARRAND.

MR. E. H. FARRAND, Executive Engineer in charge of the Leeds (External) Section of the North-Eastern Engineering District, retired on 31st December, 1924, after completing 46 years' service in the Post Office.

Mr. Farrand commenced his career at Worksop in 1878 and, coming under the notice of the late Mr. G. H. Comport, Superintending Engineer of the North Midland District, was transferred to the latter's Headquarters at Nottingham in 1885. He was promoted subsequently to the position of Chief Clerk at Leeds, but his natural bent was towards an active share in the construction work of the Department and he received his appointment as Second Class Engineer at Middlesborough in 1895. Afterwards he served under the late Mr. G. M. Carr, Superintending Engineer of the North Eastern District, who had many similar personal characteristics, including an earnest desire to improve the methods of open line construction and maintenance, and Mr. Farrand had a great deal to do with various improvements relating to the construction of open lines.

Mr. E. H. Farrand.

In 1904 Mr. Farrand was appointed 1st Class Engineer at Leeds, taking over three second class Engineers' Sections. It was in this capacity that he became widely known not only in Leeds and the West Riding of Yorkshire but to engineers in different parts of the Country, as Leeds has always been an important Telegraph and Telephone Station. His activities have been many, but, to the last day of his service, his energy, cheerfulness, and goodwill remained unimpaired. It made no difference whether the work at the moment related to the efficiency of a leading-in insulator or to a complicated rearrangement of wires for a change over from "Manual" to "Automatic"—his enthusiasm and experience overcame all difficulties.

The years from 1911, following the acquisition of the late N.T. Company's plant, have been strenuous ones for most Post Office Engineers due to the need for developing the local telephone system by providing plant to meet the increasing demands of the service. Here, again, Mr. Farrand set an example by devoted attention to the many schemes of development in his Section and, at the same time, carried out an extensive re-arrangement of local underground plant to facilitate the conversion of Leeds Exchange from Magneto to Automatic Working. Much more might be written, but it is sufficient to state that Mr. Farrand's high ideals of construction and maintenance methods were a great asset to the Post Office in the first trial of Automatic Telephone working in a large industrial city.

Mr. Farrand in his leisure hours turned to the country side. His knowledge of the old roads—particularly Roman—was extensive, and his love of nature showed him to be a disciple of Borrow, although his trusted cycle carried him at greater speed than was accomplished by the East Anglian Master in his day. Towards the close of his official career Mr. Farrand combined with his first love the cultivation of an allotment and the exhilaration of driving a small car.

His colleagues wish him happiness in his retirement and as he is in good health and spirits no doubt his energy will follow new paths. He will be remembered as one ever ready to serve the Department and to assist his colleagues.

G.M.B.

MR. C. H. CHAPMAN.

On the 14th December, 1924, Mr. C. H. Chapman, the Executive Engineer in charge of the Engineer-in-Chief's Instrument Testing Branch, Studd Street, retired at the age limit, having completed 43 years' service. Being attached for 32 years to the Testing Branch, a training ground for many Engineers who have risen to prominence, Mr. Chapman will be remembered by colleagues now scattered all over the country as a genial and true friend.

A large number of past and present members of the Testing Branch assembled in the dining room at Studd Street to bid him farewell. The presentation of a silver salver, suit case and autograph album was made by Mr. F. L. Henley, Staff Engineer, Test Section, who, in the course of a felicitous speech, thanked Mr. Chapman for the great and valuable assistance he had rendered, and instanced the phenomenal growth of the work of the Section, the staff of which in his early days numbered less than a dozen officers now amounted to several hundreds.

The Album bore the inscription as follows :—

"This Album contains the signatures of those colleagues of

MR. CHARLES HENRY CHAPMAN,

who were associated with the presentation to him of a Silver Salver and a Suit Case on the occasion of his retirement from the Engineering Department of the Post Office at the age of 60 years.

His colleagues desire to express to him their cordial good wishes for a long and happy life. They recall with satisfaction the amicable relations that have always subsisted between him and them during his long service of 43 years and they regret that the time has come when their official relations with him must cease. In bidding him farewell they wish him the best of health to enjoy his well earned leisure."

I.P.O.E.E. LOCAL CENTRE NOTES.

NORTH WALES CENTRE.

At the meeting at Shrewsbury on 16th December, 1924, the Centre was favoured with a visit from Mr. J. E. Statters, A.M.I.E.E., of the Engineer-in-Chief's Office, who read a paper on "Telephone Transmission." Mr. T. Plummer, M.I.E.E., Chairman of the Centre, presided.

The paper dealt in detail with the methods used at Headquarters in calculating the impedances of circuits made up of different classes of conductor, and with the effects of changes of line impedance upon the final transmission efficiency of the whole circuit. The question of the design of a telephone which would meet efficiently the widely different combinations of line and terminal impedances through which it is required to operate from minute to minute, was touched upon. The lecture was illustrated by many lantern slides and blackboard calculations and an animated discussion followed.

The Centre met on 13th January, 1925, to hear a paper read by Mr. J. C. Spiers on "The Advantages of the Universal Fault Locator compared with the Wheatstone Bridge or Bridge Megger."

The paper was introduced by a description of the Slide Wire and the methods of localising faults. Each class of fault was dealt with and the accuracy of each method compared. The double loop test was also referred to. Dealing with disconnections, examples of capacity tests with the Slide Wire on short or on long distances were given. Finally, Mr. Spiers touched on the localisation of high resistance loop faults, and explained by means of lantern slides the theory of the tests taken.

On 10th February, 1925, a discussion was opened by Mr. W.

Dunnet, who read a paper on " Departmental Regulations and Present Day Practice."

He was critical of the issue of the large number of books, instructions, pamphlets, cards, etc., for the guidance of the staff, and doubted the wisdom of the new form of Regulations. The lecturer considered that the publication of so many shortlived circulars tended to bewilder and confuse the staff, and to undermine initiative, and instanced the number of circulars on the subject of the provision of Rural Exchanges. Standard Tool Lists present and prospective were held to be ineffective.

The intricacy, complexity, and minuteness, of the accounting system in his opinion directly retarded output, and the workmen grades were called upon to do too much writing. It was considered that the attempts which were made to cover every contingency by an instruction of some character stood condemned. The examinations of District Accounting procedure were also in his opinion far too microscopic. He stated that records showed that the annual increase in motor vehicles in this country exceeds the yearly addition to the number of telephones installed, despite the cost of the respective services.

To effect improvements in some of these matters he advocated the automatic cancellation of every circular after 12 months from the date of issue, or alternatively its reissue and redating. Systematic Tool Checks which were costly and raised interminable correspondence should be abolished, the workmen being held responsible for the surrender of his kit intact at any time. Greater facilities for the loan of tools from Stock was also recommended.

Extension of the " Small Stores " schedule to reduce accounting transactions and the use of average prices for certain classes of inexpensive stores were also advocated.

To simplify the staff records it was suggested that increases of wages particularly of the unestablished Staff should be granted on 1st January.

Finally, the lecturer recommended serious consideration of a proposal to reduce the number of forms issued in connection with Advice Notes.

SOUTH MIDLAND CENTRE.

Although the opening meeting of the 1924-25 Session was held on the day of the general election (29th October, 1924) the large number of 69 members and visitors were present at this, the 46th meeting of the South Midland Centre.

The Vice-Chairman, Major G. H. Comport, took the chair, and the Chairman of the Centre, Mr. J. E. Taylor, read a paper entitled " Some Electrical Fallacies."

Misconceptions commonly held about the alterations in the magnetic field of telephone receiver magnets, the actual function of induction coils and condensers in telephone subscribers' sets and the real purpose of heat coils were cleared up. The lecturer, passing on to wireless fallacies, dealt with this section of his subject under the headings of the damping of the plain aerial transmitter, spark gap resistance, counterpoise substitutes for earth, coupling waves, defective earthing methods, land and sea wave-absorption, the Heaviside layer and conduction by gases.

The theory of high frequency alternators and harmonics was set out and the paper ended with an account of some difficulties which appeared to the lecturer to be encountered in the full acceptance of the electronic theory of electric currents. Alternative views were explained. The lecture was illustrated by lantern slides and numerous blackboard sketches.

Opinions were offered and questions asked by Messrs. J. S. Brown, Dwyer, Atkins, Wakefield, Halton, and Major Comport, to each of whom the lecturer replied.

Major Comport aptly concluded a most successful and instructive meeting by assuring the lecturer that the enthusiastic applause had conveyed to him the thanks of the audience in a more pleasing manner than a formal vote of thanks.

On the 26th November, Mr. A. B. Eason, of the Equipment Section, Engineer-in-Chief's Office, lectured on "Power Plant in C.B. and Automatic Exchanges."

The author dealt with the following items seriatim—standard voltages, battery capacity, counter E.M.F. batteries, meter and booster batteries, types of battery "boxes," control of charge of batteries, cabinets for battery fuses, distilled water and storage of water, oil on batteries, charging machines, piers of charging machines and ringers with special reference to anti-vibration devices, earthing brush on flexible coupling, power board and switch gear, knife switches, discharge circuit, voltage drop in fuses, instruments on power board, power cables to fuse panels, ringing machines and interrupters. The lecture, which was illustrated by 26 lantern slides, was closely followed by the audience, and the following members joined in the discussion or asked questions: Messrs. Halton, Wood, Gravill, Wakefield, Atkins, and the Chairman. Mr. Eason suitably replied, and the meeting closed with a cordial vote of thanks.

A large number of members and some specially invited visitors were present on the 31st December to hear Captain P. P. Eckersley, Chief Engineer of the British Broadcasting Company, speak in a humorous and extremely interesting manner about "The Troubles of Broadcasting." The lecturer outlined the progress of wireless telephony since 1913, making particular reference to the advent of the B.B.C. in November, 1922. The problems solved and unsolved which come before the Company were described in a racy manner.

Captain Eckersley spent some time in explaining the apparatus at the studio used in conjunction with the Post Office in order to give a simultaneous broadcasting service. He admitted that without the co-operation of the Post Office Engineers simultaneous broadcasting would not be possible and expressed the hope that the sympathetic consideration uniformly given by Post Office officials to the B.B.C. staff would continue. A number of slides showing the special apparatus at the studios was exhibited on the screen.

Captains Horton and Pope, Messrs. J. S. Brown and A. Gwilliam and the Chairman contributed to the discussion. The vote of thanks to Captain Eckersley, which was proposed by Major Comport and seconded by Mr. J. S. Brown, was endorsed by the audience with loud and lengthy applause.

Mr. J. E. Statters, of the Telephone Section, favoured the Centre on the 28th January by reading his paper entitled "Telephone Transmission." He explained the table of constants for equivalent "T" and "Π" circuits which he had prepared for use in cases of lengths up to the equivalent of 15 miles of standard cable.

Mr. Statters continued by describing the arrangement for comparing the volume of speech received over circuits under test. The differences between the British, Continental and American transmission units were explained and interesting details were given of the efforts which are being made to obtain international uniformity. The values of terminal losses in various types of circuits were computed and examples of mathematical investigations into transmission efficiency given.

The lecture was illustrated by diagrams, blackboard sketches and slides projected on to the screen.

Mr. Statters expressed himself as willing to endeavour to answer any question relating to telephone transmission, even if the points raised had not been touched upon in his lecture and he replied to the questions asked by Messrs. Beaumont, Atkins, Halton, Captain Linsell and the Chairman.

The Chairman cordially thanked Mr. Statters on behalf of the audience.

At the February meeting, held on the 25th of that month, Mr. J. S. Brown, of Southampton Section, gave an interesting account of some part of his official experiences in a discourse entitled "Submarine Cable Work in Tidal Waters."

The lecturer, adapting a breezy conversational style which obviously gained and retained throughout the close attention of the audience, commenced by explaining the method of laying new cables and recovering an old cable across the comparatively short width of the River Medina at Cowes. He continued by demonstrating how the Hayling Island cable was laid from a sand lighter across Langston Harbour, where the flow of the tides is exceptionally strong. Mr. Brown next described the more extensive work at the Itchen Ferry of laying two temporary cables, recovering old cables, laying the permanent cables and recovering the temporary cables. The description of the ingenious use of the Floating Bridge cable in the recovery of the old telegraph and telephone cables gained expressions of appreciation.

The next point dealt with was the arrangement adopted for repairing faulty submarine cables, and Mr. Brown showed clearly by demonstration with the aid of short lengths of cable the manner in which this work was accomplished.

The description of the repairing of the cables at Horseand Fort was so realistic that the audience in their lecture-room seats shared long after the event a weird and eerie adventure which Post Office Engineers rarely have an opportunity of experiencing.

The lecture concluded with a few maxims which Mr. Brown had found to be necessary in carrying out submarine work successfully. A large number of fine slides was shown on the screen.

Captain Pope, Mr. Gravill, Mr. Halton and Major Comport asked questions and each congratulated Mr. Brown on the success of his effort. The Chairman, in closing the meeting, aptly stated that the discourse carried with it a tang of salt breezes. Mr. Brown was thanked by enthusiastic applause from the audience.

(Mr. Brown's paper is dealt with more fully elsewhere in this issue).

A.W.L.

SOUTH LANCS. CENTRE.

Since the last notes were written four papers have been read before this Centre, viz.:—

December 8th. "The Importance of Detail in Radio Reception." J. H. Reyner, B.Sc., Engineer-in-Chief's Office.
January 12th. "The Baudot Telegraph System." R. J. Vernon.
February 9th. "Telephone Transmission." J. E. Statters, Engineer-in-Chief's Office.
February 23rd. "Automatic Telephones." H. H. Harrison, M.I.E.E., of the Automatic Telephone Co.
March 9th. "Cutting in Working Circuits on Underground Cables." J. W. Thompson.

In each case the papers were of an exceptionally high order of merit and have been followed by keen discussions. The latter feature is particularly gratifying not only as a tribute to the ability of the lecturer, but as showing that the subjects were well chosen from the point of view of general interest and utility. Frequently the discussion produced further contributions of value.

Thanks to the lecturers were suitably voiced by proposers and seconders on each occasion and were cordially endorsed by the members and visitors present.

On February 23rd arrangements were made, by the courtesy of the Automatic Telephone Co., for a visit to their works at Milton Road, Edge Lane, Liverpool. The Company spared no pains to make the visit a success and the members who were privileged to participate spent a very enjoyable and profitable afternoon. The demonstration set which had been on view at Wembley, showing the working of the director system, proved to be particularly interesting.

In the January issue of the Journal mention was made of an invitation received from the Institution of Electrical Engineers to attend a lecture by Prof. G. W. O. Howe, of the University of Glasgow, and of the Radio Research Board, on " World Wide Radio Telegraphy," to be delivered on January 6th. The invitation met with a generous response from this Institution and the large hall hired specially for the purpose was well filled. The Chairman, Mr. H. C. Lamb, M.I.E.E., in his opening remarks, stated that it gave the I.E.E. special pleasure to be able to attend a joint meeting with the Post Office Engineers and thus to make some return for the interesting lecture which the I.P.O.E.E. had, last year, provided when Capt. P. P. Eckersley, M.I.E.E., Chief Engineer of the B.B.C., visited Manchester. He expressed the hope that a similar event would become an annual feature.

NORTHERN CENTRE.

Since writing the last notes two of our members, Major G. A. Blackwell and Mr. J. H. Clark, have left this District on promotion. Both officers took an active interest in the activities of the local centre and we are sorry to lose them. Mr. Clark served on the Local Committee as the Draughtsmen's representative.

At the December meeting of the Centre, Mr. J. Irvin Smith read a paper entitled, " A Village Automatic Exchange." The lecturer described the recently erected Exchange at Marton, in North Yorkshire, which is one of the five unattended exchanges at present in this country. The paper was fully illustrated with slides and the lecturer was complimented upon his instructive, interesting and well written paper.

The members of the Centre were invited by the Institution of Electrical Engineers to a Faraday Lecture on the 17th December, when Professor B. W. O. Howe gave a lecture on "World Wide Radio Telegraphy."

On the 17th January, the Centre had the pleasure of entertaining a party of visitors from The Junior Institution of Engineers. The visitors were shown over the Instrument Room at Newcastle P.O., and were afterwards entertained to refreshments. A full account of the visit is recorded in the current issue of the Journal of the Junior Institution of Engineers.

Mr. J. M. Markey read a paper on "Faults—Their Prevention and Cure," at the January meeting of the Centre, and a spirited discussion ensued. The paper was practical, original and well delivered.

On February 18th, Mr. C. H. Lunn read a paper entitled, "Drawing Office Methods and their relation to the special work of the Department." The paper provided a good discussion and several of the suggestions made respecting Drawing Office conditions are being considered for adoption by the Chairman.

The Junior Institution of Engineers has extended a cordial invitation to I.P.O.E.E. members to attend a lecture to be delivered on March 20th, at 7.15 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle, by Mr. R Dowson. The subject will be "Steam Turbines," and the lecture will be illustrated by a Cinematograph Film showing the construction of a 50,000 K.W. Turbine. This will be the first occasion on which the film has been publicly exhibited.

NORTH EASTERN DISTRICT CENTRE.

A most successful Session terminated on the 9th March last, when the Centre was favoured with a visit from the Council.

On this date Mr. Hunsworth read a paper on "Annual Estimates," and between the reading of the paper and the discussion tea was taken and this proved an opportunity to mingle.

Mr. T. B. Johnson welcomed the Council, specially referring to Mr. De Lattre and Mr. Shaughnessy. The latter in replying for the Council was in his happiest mood. The whole Centre rocked with laughter at the delicious humour, whilst the sound commonsense contained in the speech won admiration on all sides. Never in the history of the local Centre has a speech been so thoroughly enjoyed. This is saying a great deal, when it is recollected that in this Centre we have a Chairman who is a past master at the game, one who knows what to say and when and how to say it.

After tea Mr. De Lattre opened the discussion and in characteristic language gave us some Headquarters views on the subject of

" Annual Estimates," which were very illuminating and helpful.

Mr. Wilby in joyous mood is always worth a hearing, and in his sonorous style he explained how in his travels he found men following lonely trails in the hunt after elusive details which they considered necessary to the make up of Annual Estimates.

We have often wondered what Hansford was like, and when a dark sharp-featured young man got on his feet we at once realised there was a new force behind the Council. He appeared to be made of springs of the best quality, capable of taking a lot of jarring and of returning to the original position in readiness for the next jar. Always wound up and ready to do all the work in a pleasant noiseless fashion.

Altogether it was a great evening, enjoyable and helpful to the good feeling amongst men who do not meet frequently but who are known to each other on paper. We saw through a glass darkly (incidentally the meeting was held at the Y.M.C.A.) and now we see face to face . . . we are known and they are known as they really are.

During the Session we have had papers on "Contracts," "P.O. Engineering Department 1885-1925," "Drawing Office Organisation," "Responsibilities and Outlook of Electrical Engineers," "Telephone Transmission," and " Annual Estimates," and the lecturers have been a Superintending Engineer, two Executive Engineers, a Principal Clerk, a Supplementary Clerk, and a Draughtsman, and therefore, it will be seen that the Committee of the Centre has been alive to the requirements of the members.

SCOTLAND WEST CENTRE.

For our fixture on 2nd February the lecturer was Mr. Arnold. The subject originally selected " Local Baudot Developments " was departed from in favour of " Tester No. 42 and Oscillator, No. 2A," it being thought the latter subject would appeal to a wider circle. The lecturer first of all described the features of the apparatus, then explained by means of diagrams the circuit of the set, and showed how it should be used to measure transmission losses in apparatus and circuits; also for the location of faults. The lecturer, in the clearest possible manner, gave the meeting the benefit of the experience gained by him from the making of tests. Experience with the apparatus in this District being, in the meantime, restricted there was little criticism, but the general opinion was that such a piece of apparatus was necessary and that it would go far towards assisting to eliminate transmission losses in exchanges.

Mr. Statters, of the E.-in-C's staff, was the lecturer at our meeting on 2nd March, the subject being "Telephone Transmission." As the lecture is being repeated at other Centres there is no need for lengthy reference here. The lecturer proved himself a master of the subject and sustained the interest of the meeting throughout. Several questions were raised and these the lecturer disposed of. On conclusion, the Chairman congratulated Mr. Statters on his lucid treatment of the subject and a hearty vote of thanks was accorded.

BOOK REVIEWS.

"Mathematics for Technical Students." By E. R. Verity, B.Sc., A.R.C.Sc. Longmans Green & Co., London. Price 12*s*. 6*d*. net.

This book is written primarily to meet the needs of students in the evening classes of Technical Institutions. It covers the usual groundwork of Algebra and Trigonometry, and the fundamental principles of the Differential and Integral Calculus are simply explained. One of the prominent features of the book is the large number of worked examples in illustration of the text. A large number of unworked examples is also given, the solutions of which are to be found at the end of the book. The practical examples will in general appeal rather to the Mechanical than the Electrical student. Although it cannot be said that the book fills any new rôle, it can, nevertheless, be recommended especially to the home student as a good guide to the elementary principles of its subject.

"Junior Technical Electricity." By Robert W. Hutchinson, M.Sc., A.M.I.E.E. W. B. Clive. University Tutorial Press, Ltd. 382 pp. 4*s*. 6*d*.

This book has been designed to provide a first year course in Electrical Engineering for students at technical schools and colleges. Special stress is laid upon the clear presentation of the fundamentals of electrical theory, and this the author has certainly succeeded in doing. No previous knowledge of the subject is assumed, and the student is led step by step from the most elementary ideas of magnetism and electricity to the stages where the knowledge acquired in the course of his reading is applied in a practical manner to the electrical appliances now in every day use. Numerous worked examples are interspersed throughout the work, and the various chapters are followed by questions and exercises on the preceding matter. The treatment of Telegraphy and Telephony is, however, of the most meagre description; but wireless theory and circuits are fairly satisfactorily dealt with in the thirteen pages allotted to them. Students reading for the City and Guilds Examinations in these subjects will find this volume a helpful adjunct to their usual class text-books.

The book is excellently printed and the many diagrams and illustrations are clearly reproduced.

A.F.

"Alternating Current Rectification." L. B. W. Jolly, M.A. (Cantab.), M.I.E.E., Assoc.M.Inst.C.E. Chapman & Hall. 25*s*. net.

The subject of Alternating Current Rectification covers practically the whole field of Electrical Engineering, and it is a matter of wonder that Mr. Jolly has managed to confine himself to one volume of 350 pages of a reasonable type and to find room for 244 splendid clear figures. The book touches on such diverse subjects as harmonic analysis, the choice of type of instrument to be used in a rectfiied current circuit, commutation, the testing of rotary converters, synchronous commutator rectifiers, the theoretical analysis of the mechanical vibration of a reed, Mercury vapour rectifiers, smoothing circuits for a rectifier installation, Neon tube, vitrating flame and corona rectifiers, electrolytic rectifiers, triode and crystal rectifiers in wireless receivers; but although such a wide range is covered the author has concerned himself strictly with his subject and has produced a splendid concise volume on present day electrical engineering practice written from the particular new point of "Rectification." The author is to be thanked also for a very good bibliography, well arranged with cross references to Science Abstracts.

The author, however, in his introduction, leaves his mathematical and practical facts and expresses opinions which will not be generally accepted without question. He states, "it is apparent that where one requires a large high voltage, direct current output of more than one or two kilowatts no immediate solution of the problem exists." The difficulties of insulation are *not* sufficient to justify the statement:—' High voltage direct current generators are anathema on account of the necessity of insulated bedplates for series operation," and there seems to be no practical reason why the system so condemned should not be a sound commercial proposition. And the thermionic rectifier *is* a good and reliable method of providing power to a wireless transmitter, although the author states: "its short life, . . . comparative uncertainty in action, and its inefficiency combine to render it unsuitable for high power conversion." It is suggested that the very short introduction might well be reconsidered and written more explicitly before the issue of a second edition.

The reviewer has a profound admiration for the scientific engineer who is also a Greek scholar, but he hopes that this book will not set a fashion of dedicating engineering books in Greek (without a translation !). The engineer has by nature a curious and enquiring mind and it is thought that his curiosity might well be spared this whetting.

R.V.H.

BOOKS RECEIVED.

" A Four-Valve Combination Receiver." W. James. 2*s*. The Wireless Press, Ltd. A 4-colour wiring diagram and complete working lay-outs facilitate the construction of this set. Switches are provided for two, three or four valves to be used at will.

" Four First Steps in Wireless." H. S. Pocock. 9*d*. The Wireless Press, Ltd.

" The Wireless Annual for Amateurs and Experimenters, 1925. 2*s*. 6*d*. The Wireless Press, Ltd.

" Post Office Technical Instructions, V.—The Wheatstone Telegraph System." New edition. 3*s*. 6*d*. net, postage extra. H.M. Stationery Office, Adastral House, Kingsway, W.C.2. Copies may be obtained from the following :—

U.S.A. The British Library of Information, 8th Floor, 44, Whitehall Street, New York.

Canada. Messrs. Wm. Dawson & Sons, Ltd., 19, Bisson Street, Montreal.

India. Messrs. Thacker, Spink & Co., Calcutta.

New Zealand. The Government Printer, Printing & Stationery Dept., Wellington.

South Africa. Messrs. Wm. Dawson & Sons, Ltd., 29/31, Long Street, Cape Town.

" The History of the Telephone in the United Kingdom." F. G. C. Baldwin. 42s. net. Chapman & Hall.

" Wireless Valve Receivers and Circuits. Tuning Coils and Methods of Tuning. The Home Constructive Easy-to-build Sets." Iliffe & Sons, Dorset House, Tudor Street, E.C.4.

" Mechanical Design of Overhead Transmission Lines." Painton. Chapman & Hall.

STAFF CHANGES.

PROMOTIONS.—continued.

Name.	Grade.	Promoted to	Date.
Falconer, A.	S.W.1. Scot. East. District.	Inspector, Scot. East District.	25-8-24
Rudger, J.	S.W.1. Scot. East. District.	Inspector, Scot. East District.	22-9-24
Swain, T. B.	S.W.1. S. Wales District.	Inspector, S. Wales District.	20-12-24
Ballett, S.	S.W.1. S. Wales District.	Inspector, S. Wales District.	21-12-24
Ives, B. J.	S.W.1. S. Wales District.	Inspector, S. Wales District.	25-8-24
Bowles, J. T.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	18-11-24
James, W. H.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	24-12-24
Rees, H. W.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	5-1-25
Winson, T. H.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	5-1-25
Courtis, F. J.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	5-1-25
Coote, F.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	5-1-25
Dilkes, G. H.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	5-1-25
Skeet, T. S.	S.W.1. N. Mid. District.	Inspector, N. Mid. District.	18-2-25
Holden, G.	S.W.1. N. West. District.	Inspector, N. West. District.	25-8-24
Edwards, F.	S.W.1. N. West. District.	Inspector, N. West. District.	14-12-24
Gregson, A.	S.W.1. N. East. District.	Inspector, N.E. District.	1-1-25
Taylor, W. H.	S.W.1. S. Mid. District.	Inspector, S. Mid. District.	14-2-25
Knight, E. W.	S.W.1. S. Mid. District.	Inspector, S. Mid. District.	28-12-24
Harknett, W.	S.W.1. S. Mid. District.	Inspector, S. Mid. District.	14-2-25
Branson, J. W.	S.W.1. S. Mid. District.	Inspector, S. Mid. District.	4-1-25
Fletcher, J.	S.W.1. N. District.	Inspector, N. District.	1-1-25
Biggs, F. J.	S.W.1. Met. Power District.	Inspector, Met. Power District.	8-12-24
Martin, W. G. B.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25
Brayley, J. W.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25
Franklin, E. C. J.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25
Jenkins, W. J.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25
Scott, T. A.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25
Williams, A. J.	S.W.1. S. Wales District.	Inspector, S. Wales District.	27-2-25
Dixon, A. S.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25
Wooles, F. E.	S.W.1. S. Wales District.	Inspector, S. Wales District.	5-1-25

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Shaughnessy, E. H. ...	Staff Engineer, E.-in-C. Office.	Asstant Engineer-in-Chief, (Wireless Services).	1-1-25
Lee, A. G., Major ...	Asst. Staff Engineer. E.-in-C. Office.	Staff Engineer, E.-in-C. Office.	1-1-25
Angwin, A. S., Major	Executive Engineer, E.-in-C. Office.	Asst. Staff Engineer. E.-in-C. Office.	9-3-25
Bassett, S. W. ...	Assistant Engineer, N. Mid. District.	Executive Engineer. East. District.	To be fixed later.
Taylor, J. L.	Assistant Engineer, E.-in-C. Office.	Executive Engineer. E.-in-C. Office.	1-4-25
Hansford, R. V. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer. E.-in-C. Office.	9-3-25
Aldridge, A. J. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer. E.-in-C. Office.	9-3-25
Gill, A. J.	Assistant Engineer, E.-in-C. Office.	Executive Engineer. E.-in-C. Office.	9-3-25
Blackwell, G. A., Maj.	Chief Inspector, N. District.	Asst. Engineer. N. Wales District.	24-2-25
Macleod, J. D. ...	Chief Inspector, E.-in-C. Office.	Asst. Engineer. Scot. West District.	21-1-25
Cook, A. G.	Chief Inspector, S. Lancs. District.	Asst. Engineer. S. Mid. District.	6-1-25
Munro, D.	Chief Inspector, Scot. West District.	Asst. Engineer. Scot. West District.	24-2-25
Bucklitsch, A. A. K. F.	Inspector, S. Lancs. District	Chief Inspector. S. West District.	To be fixed later.
Stewart, R. T. ...	Inspector, Scot. West District.	Chief Inspector. N. District.	do.
Cunninghame, R. J. Mc.	Inspector, Scot. West District.	Chief Inspector. N. Wales District.	do.
Cowles, H. M. ...	Inspector, East. District.	Chief Inspector. East. District.	20-2-25
Shearer, J.L.	Inspector, Scot. East District.	Chief Inspector. Scot. East District.	15-2-25
Gifford, H. W. ...	Inspector, S. Wales District.	Chief Inspector. S. Wales District.	25-8-24
Dixon, W.	Inspector, N. Mid. District.	Chief Inspector. N. Mid. District.	25-2-25
Cranfield, W.	Inspector, East. District.	Chief Inspector. East District.	4-2-25
Guy, W. H.	Inspector, S. Lancs. District	Chief Inspector. S. West. District.	
James, F. G. H. ...	Inspector. S. East. District.	Chief Inspector. S. East District.	25-8-24
Bull, W. J.	Inspector. S. Wales District.	Chief Inspector. S. Wales District.	25-8-24
Johnson, F. J.... ...	Repeater Officer, Class II. East. District.	Repeater Officer, Class I. N. Wales District.	15-11-24
Knox, A.	S.W.1. Scot. East. District.	Inspector, Scot. East District.	31-3-24
Brien, A.	S.W.1. Scot. East. District.	Inspector, Scot. East District.	25-8-24
Shaw, W. A. J. ...	S.W.1. Scot. East. District.	Inspector, Scot. East District.	26-11-24
Burgher, H.	S.W.1. Scot. East. District.	Inspector, Scot. East District.	28-2-24

STAFF CHANGES.

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From	To.	
Mercer, C. J....	Executive Engineer.	S. Lancs. Dist.	E.-in-C. Office	15-3-25
Shea, J. ...	Executive Engineer.	S. Lancs. Dist.	N. East. Dist.	1-3-25
Leigh, J. H. ...	Executive Engineer.	E. District.	S. Lancs. Dist.	8-3-25
Dawson, C. E.	Assistant Engineer.	Irish Free State.	N. Mid. Dist.	1-2-25
Spink, E. ...	Assistant Engineer.	N. Mid. Dist.	S. Mid. Dist.	15-2-25
Hill, R. J. ...	Inspector.	S. West. Dist.	E.-in-C. Office	1-3-25

RETIREMENTS.

Name	Grade.	District.	Date.
		do.	
Hunter, G.	Assistant Engineer.	E.-in-C. Office.	2-2-25
McLeish, J.	Chief Inspector,	London District.	6-2-25
Paynter, A. W. ...	Inspector,	S. Lancs. District.	1-1-25
Kirkham, F.	Inspector,	London District.	3-1-25
Ireland, J.	Inspector,	S. Mid. District.	22-1-25

DEATHS.

Name.	Grade.	District.	Date.
Guthrie, R. E.... ...	Inspector	Northern District.	1-1-25
Stevens, A. W. ...	Inspector	London District.	18-1-25

RESIGNATIONS.

Name.	Grade.	District.	Date.
Barthel, W. R. ...	Inspector	N. East. District.	25-1-25

APPOINTMENTS.

The undermentioned have been appointed Probationary Assistant Engineers as a result of the *Limited* Competitions held in November, 1924.

Name.	Grade.	Office alloted to.
Jolley, E. H.	Probationery Inspector.	Research Section.
Pidgeon, J. E.	Chief Inspector.	Research Section.
Taylor, T. A.	Probationery Inspector.	Research Section.
Jackson, J. M.	Chief Inspector.	Research Section.
Williams, Ll. E.	Chief Inspector.	Power Section.
Wallcroft, F. E.	Probationery Inspector.	Research Section.
Bedford, J. G.	Chief Inspector.	Research Section.
Missen, E.	Repeater Officer, Cl. II.	Wireless Section.
Chinn, W. E.	Draughtsman, Cl. II.	Equipment Section.

STAFF CHANGES.

The undermentioned are due to be appointed Probationary Assistant Engineers as a result of the *Open* Competition held in November, 1924.

NAMES.

Beer, H. G.
Britton, F. T.
Moffatt, C. E.
Ryall, L. E.
Semple, L. G.
Manning, F. E. A.
Bryden, J. E. Z.
Brent, W. H.
Farnes, G. H.
Gemmell, W. T.
Hines, R. J.
Dixon, G. J. C.
Gray, W. D.
Davis, T. A.
Bewick, T. A.
Barker, P. L.

CLERICAL ESTABLISHMENT.

APPOINTMENTS AS CLERICAL OFFICER.

Name.	District.	Date.
Edwards, W. J.	E.-in-C.O.	25-1-1925
Calnan, J. J.	do.	1-2-1925
Martin, H. J.	London	7-1-1925
Stanbury, G. R. W. . .	S.Wa.	1-1-1925
Lee, R.	S.Mid.	1-1-1925
Milne, J. T.	Scot. East	1-1-1925
Jackman, C. G.	S.East	4-1-1925
Moore, F. W.	S.West	4-1-1925
Kent, O. A.	S.East	4-1-1925
Livingstone, A. S. ...	N.	7-1-1925
Cameron, A.	N.Wa.	11-1-1925
Cowie, W.	Scot. East	11-1-1925
Gifford, R. J.	Eastern	11-1-1925
Postlethwaite, R. R. ...	N.W.	11-1-1925
Hamilton, J. McL. ...	N.Wa.	11-1-1925
McKenna, A. R.	Eastern	18-1-1925
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Martin, E. N.... ...	Admiralty.	S. Mid. District.	2-2-25

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Harding, H. J. ...	N. Wales District.	S. Mid. District.	1-3-25
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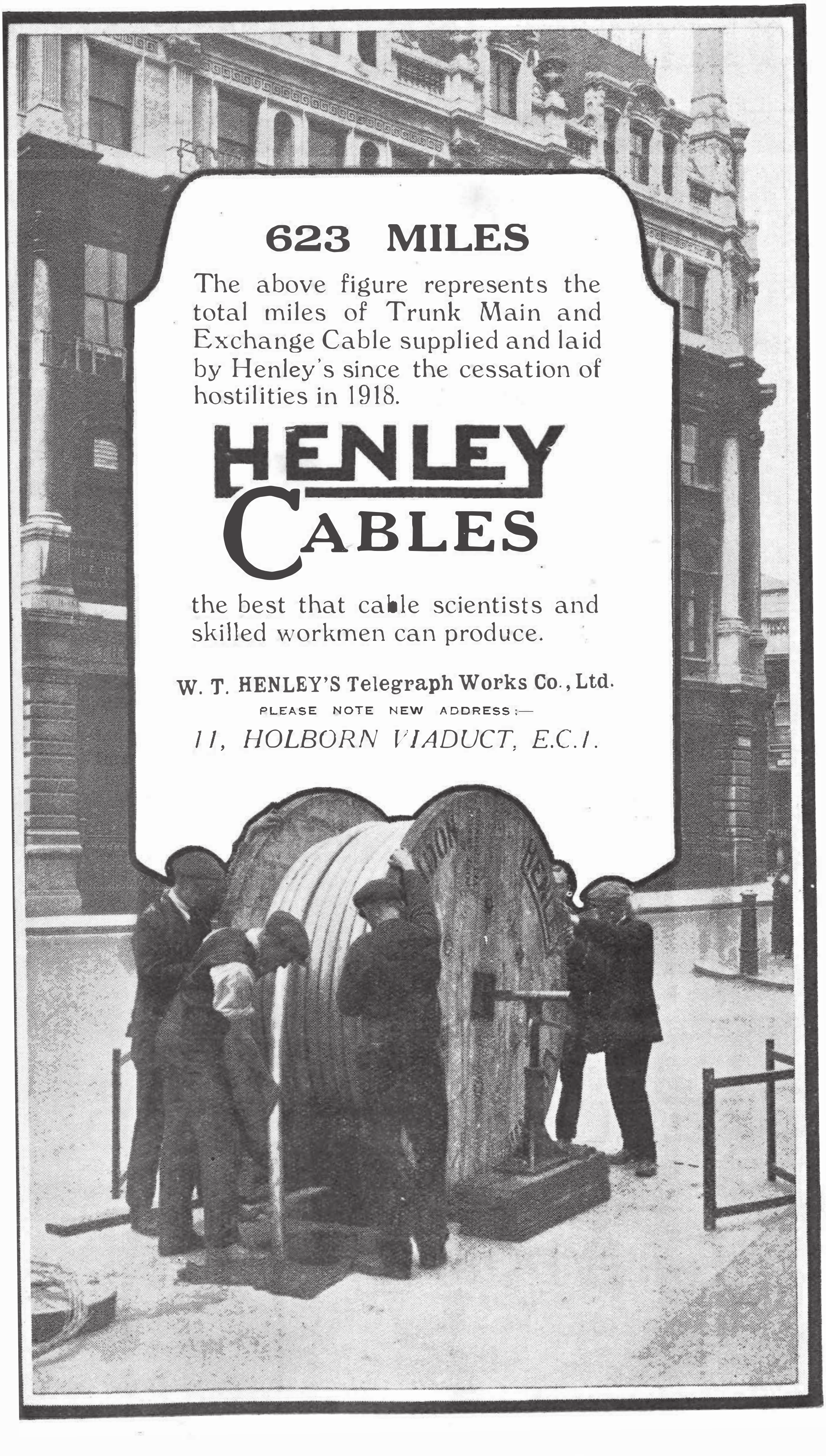

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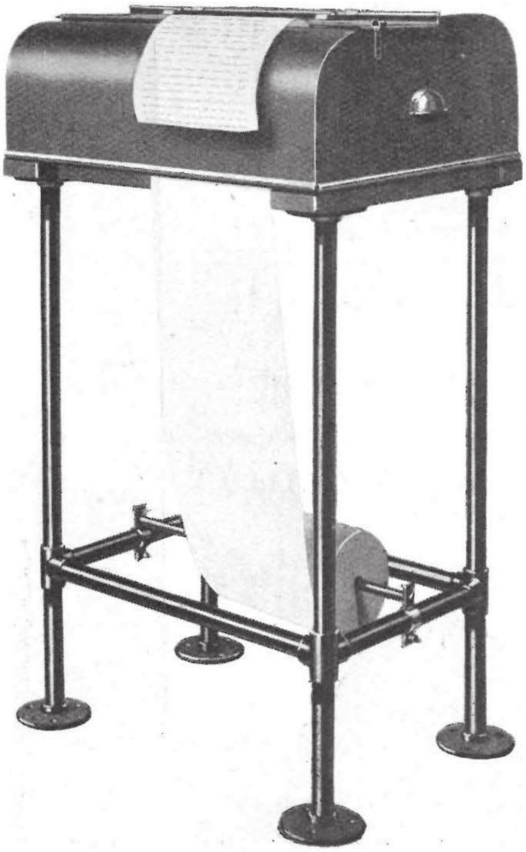

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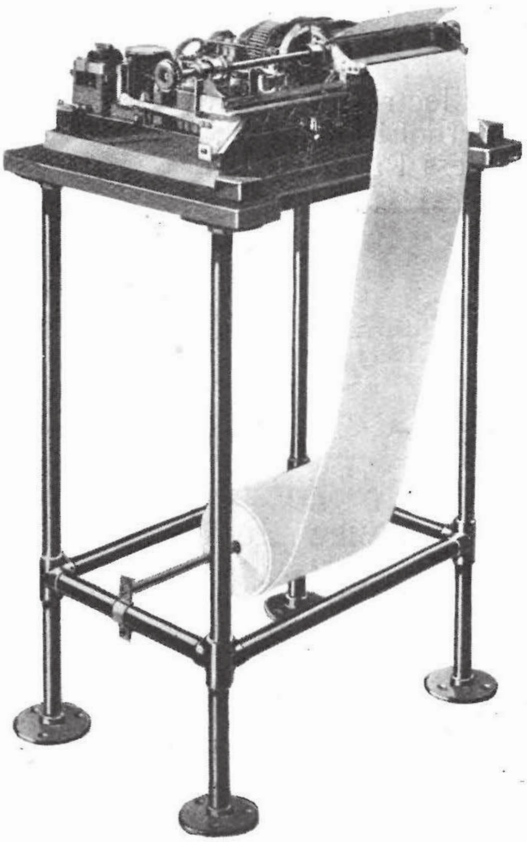

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INDEX TO ADVERTISERS.

	PAGE
Annales des Postes, Telegraphes et Telephones ...	viii
Automatic Telephone Mfg. Co., Ltd.	iii
British L.M. Ericsson Mfg. Co., Ltd.	v
Creed & Co., Ltd.	xii and xiii
Henley's, W. T., Telegraph Works Co., Ltd. ...	xi
Johnson & Phillips, Ltd.	xvi
London Electric Wire Co. & Smiths, Ltd.	ii
Peel-Conner Telephone Works, Ltd.	xv
Pitman & Sons, Ltd.	ii
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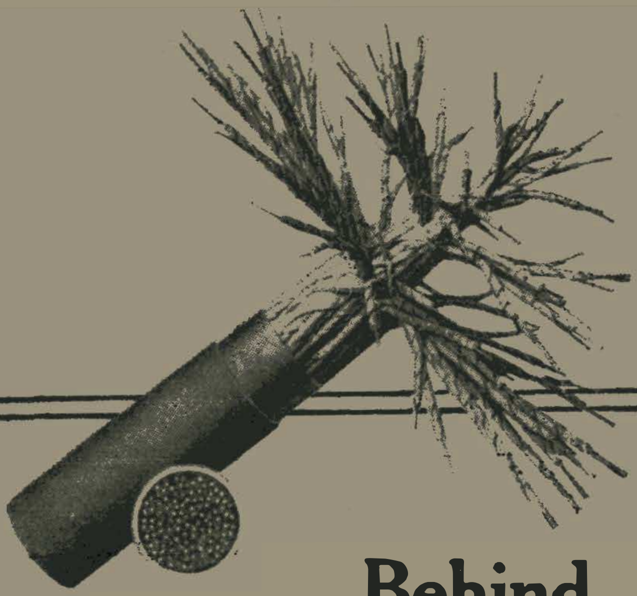

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PAGE
TELEGRAPH SUPERPOSING ON UNDERGROUND CABLES—A. C. Booth ... 115
ENGINEER-IN-CHIEF'S AUTOMATIC TELEPHONE TRAINING SCHOOL AND CIRCUIT LABORATORY—B. O. Anson, M.I.E.E. ... 117
A MONSTER TELEPHONE BATTERY ... 124
NEWPORT STROWGER AUTOMATIC TELEPHONE AREA EXTENDED 126
THE L.M. ERICSSON AUTOMATIC TELELPHONE SYSTEM ... 128
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM ... 160
THE ROMFORD TO SOUTHEND-ON-SEA LOADED AERIAL CABLE—A. W. Gardner, A.M.I.E.E. ... 161
INTRODUCTION OF UTILITY SERVICE MOTOR VEHICLE IN THE ENGINEERING DEPARTMENT ... 165
QUARTZ CRYSTAL RESONATORS—F. E. Nancarrow, A.R.C.Sc., A.M.I.E.E., M.I.R.E. ... 168
INTERFERENCE TO BROADCAST RECEPTION BY OSCILLATING RECEIVERS ... 174
NOTES AND COMMENTS ... 176
HEADQUARTERS NOTES ... 182
LONDON DISTRICT NOTES ... 183
THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS ... 186
LOCAL CENTRE NOTES ... 189
THOMAS PATTERSON ... 195
BOOK REVIEWS ... 197
STAFF CHANGES ... 206
COMMUNICATIONS ... 212

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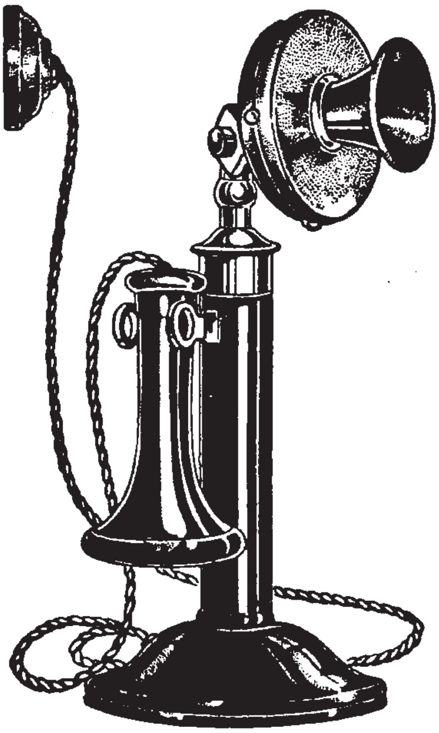

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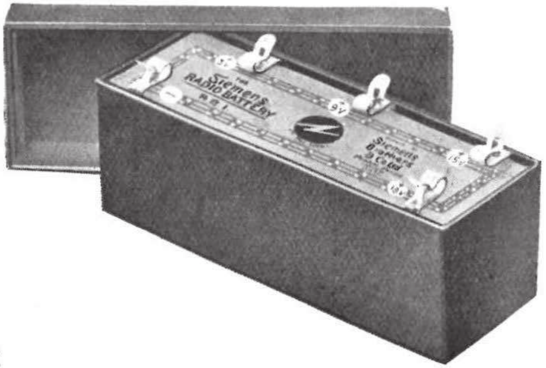

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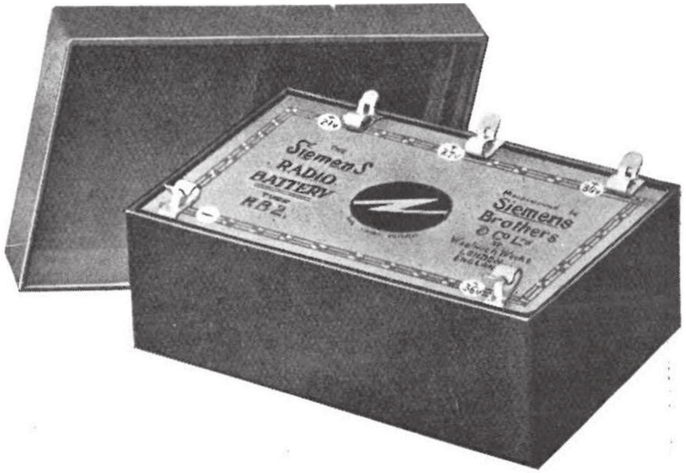

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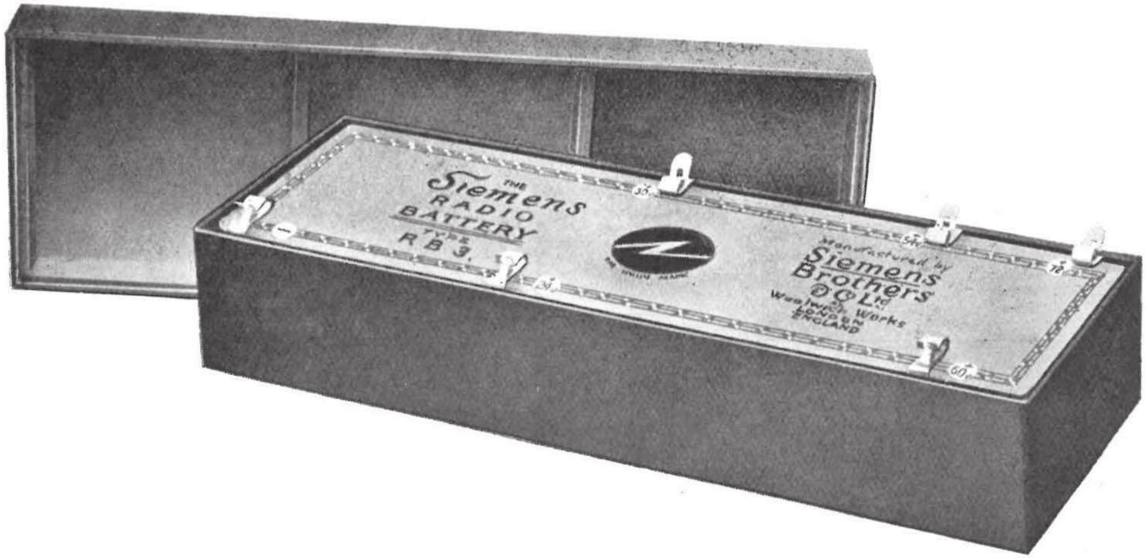
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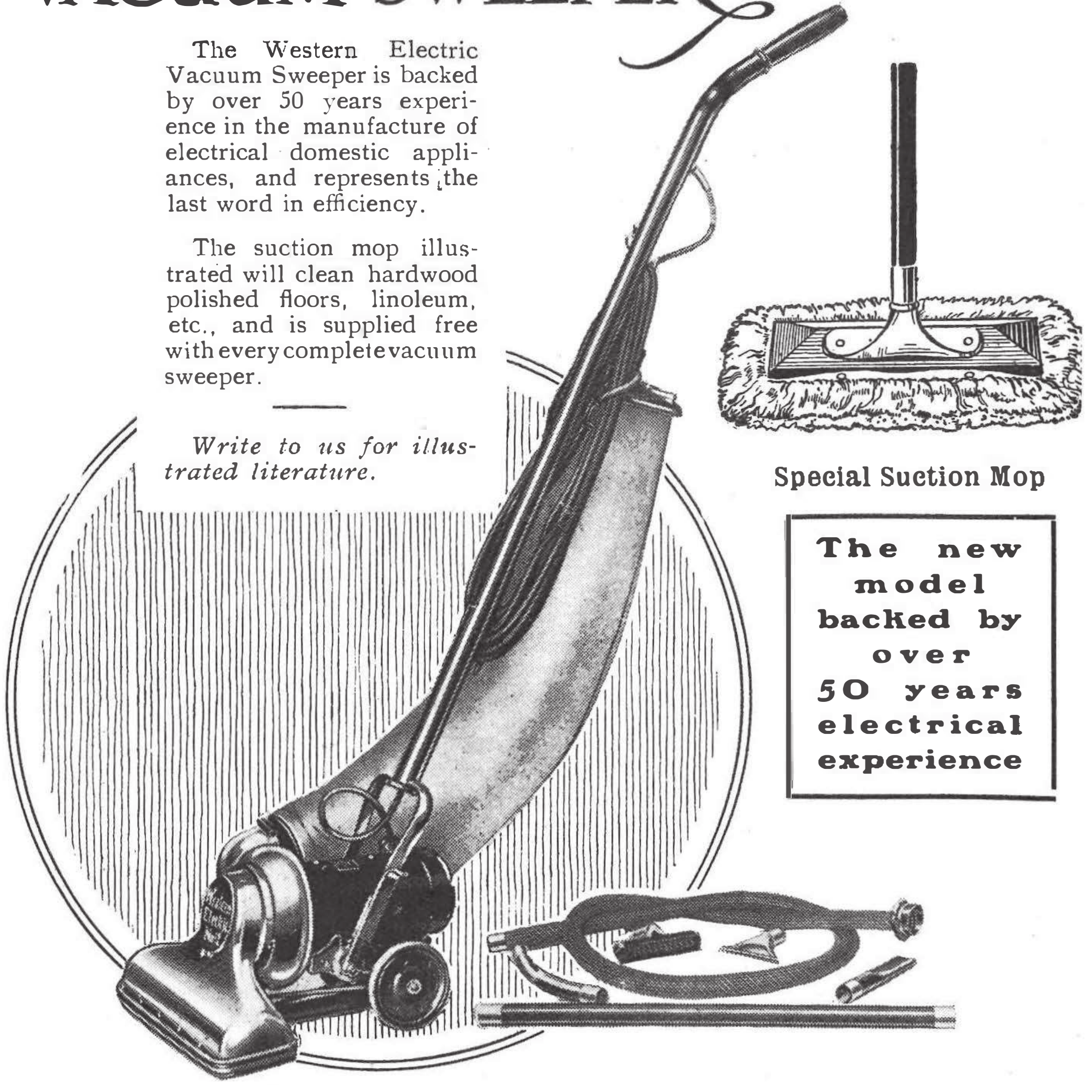

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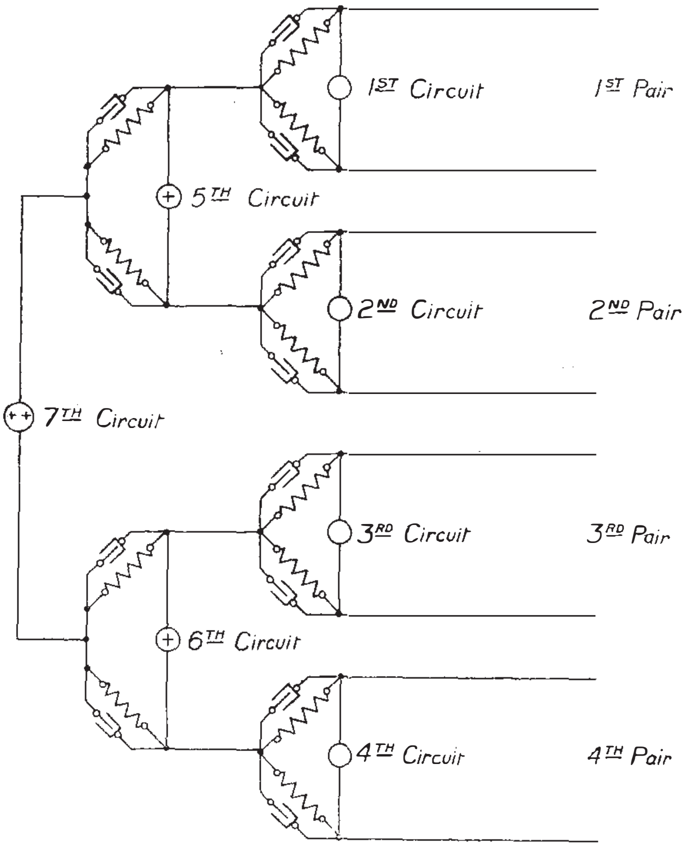

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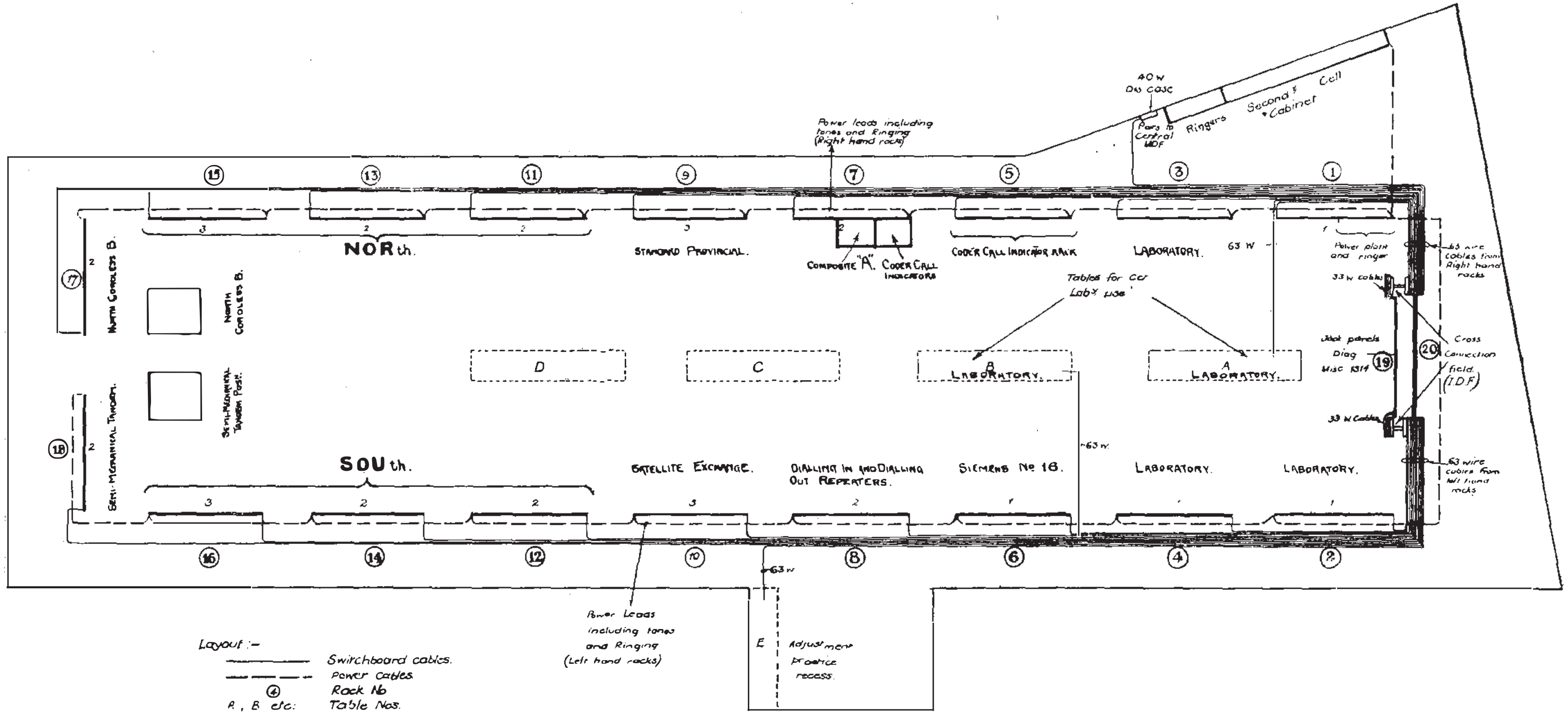

FIG. 1.—LAY-OUT OF APPARATUS RACKS.

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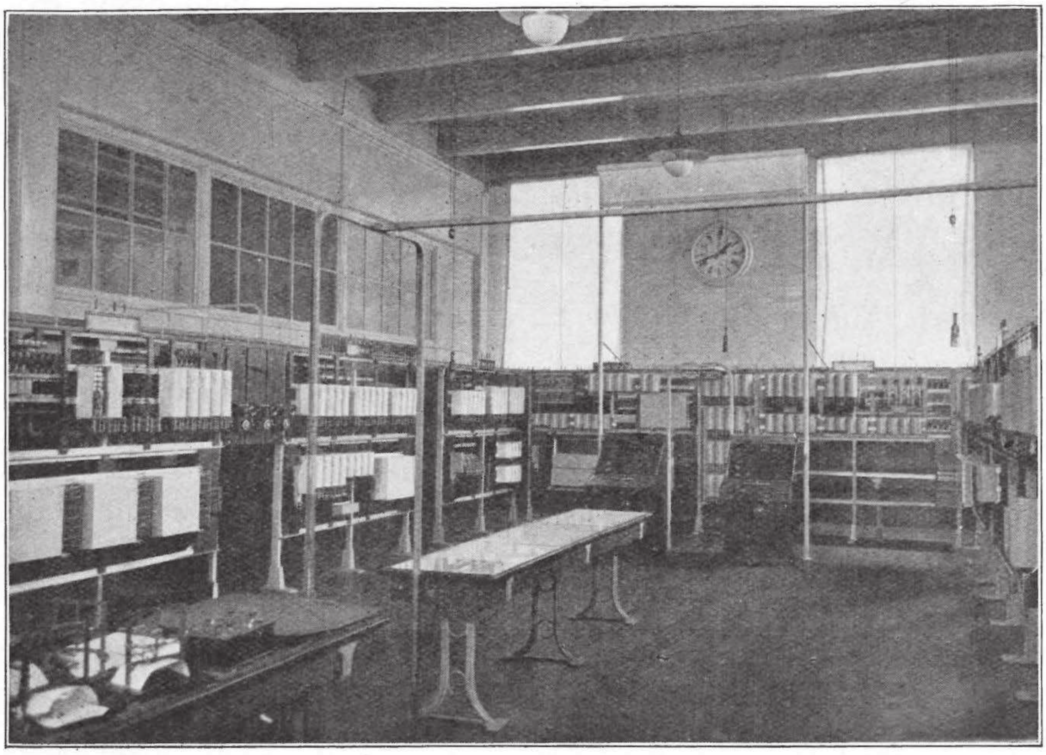


FIG. 2.—DEMONSTRATION ROOM, LOOKING WEST.

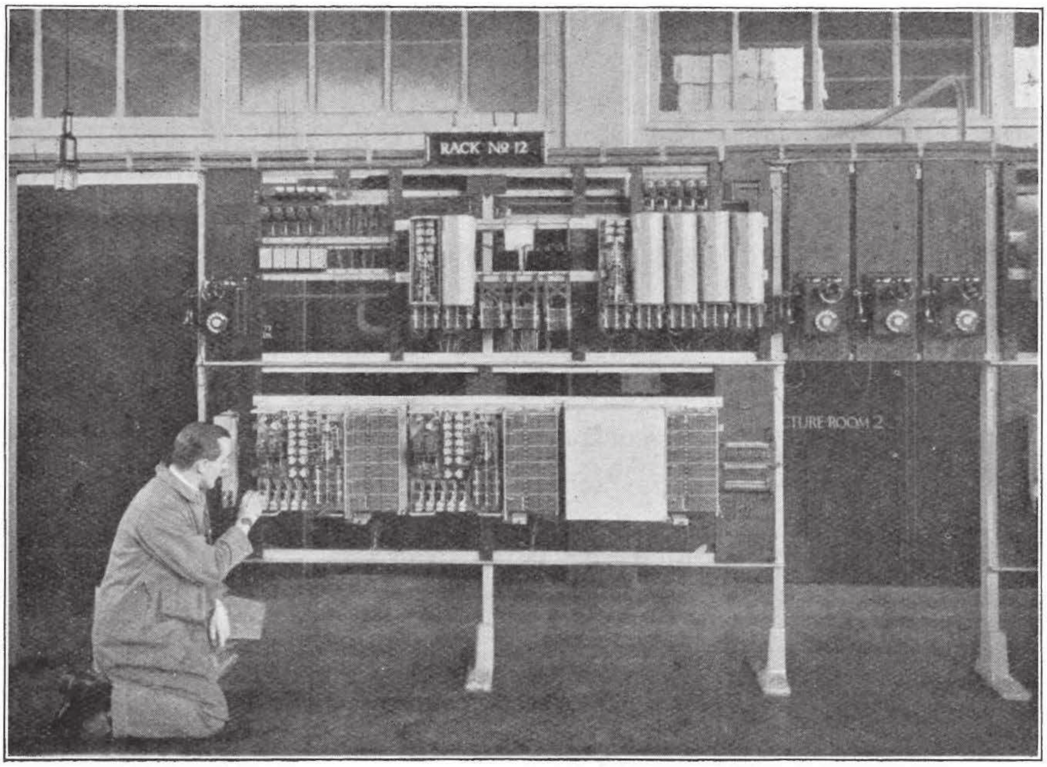


FIG. 3.—TYPICAL RACK, SHOWING 1ST CODE SELECTOR, A DIGIT SELECTORS AND DIRECTORS.

(*a*) Three racks representing a "director" automatic exchange "North."

(*b*) Three similar racks for another exchange "South."

(*c*) A Cordless "B" Position with all accessory apparatus working on "North."

(*d*) A semi-mechanical tandem cordless "B" position with accessory apparatus.

(*e*) A Satellite exchange working on "South."

(*f*) A rack representing standard provincial apparatus and circuits (non-director).

(*g*) A Composite "A" Position equipped with the various types of dialling-in cord circuits and trunks incoming and outgoing from automatic equipment.

(*h*) One rack having samples of dialling-in and dialling-out of repeaters.

(*i*) One rack representing Messrs. Siemens' No. 16 equipment.

(*j*) One Call Indicator position with accessory apparatus.

The racks in the Demonstration Room are all cabled to an intermediate distribution frame at the east end of the room, and the trunking scheme is arranged by cross-connections in the jumper field that carry the circuits through a break jack panel. It is possible, therefore, to intercept any of the circuits for Laboratory purposes and to facilitate this work the Circuit Laboratory is placed at the east end of the Demonstration Room.

Fig. **2** gives a general view of the west end of the Demonstration Room. The tables along the centre are utilised for adjustment work, but also serve as study tables, being equipped with glass tops so that a standard set of diagrams can be placed beneath the glass. The diagrams are changed to suit the current courses. The cordless "B" positions can be seen in this figure.

Fig. **3** shows a typical rack with some of the apparatus covers removed for inspection.

Fig. **4** shows the call indicator "B" position and its accessory apparatus on rack No. 5. The call indicator system adopted by the British Post Office is designed to give traffic distribution to the "B" operators and thereby permit of the closing down of positions during slack periods. This feature is illustrated in the model by the provision of a second call indicator display in the multiple panel, thus avoiding the need for installing more than one model position. This figure also gives a view of the composite "A" position.

Fig. **5** shows a group of students undergoing adjustment tuition.

Fig. **6** shows a group of students in the Study Room.

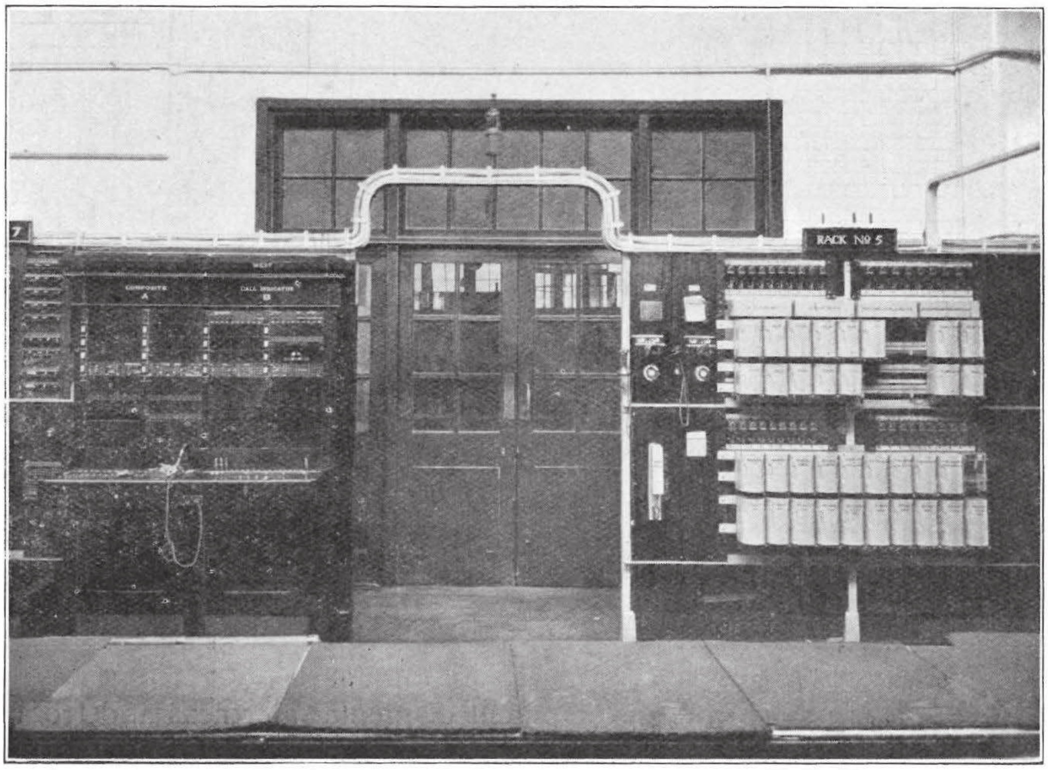


FIG. 4.—CALL INDICATOR POSITION AND ACCESSARY APPARATUS.

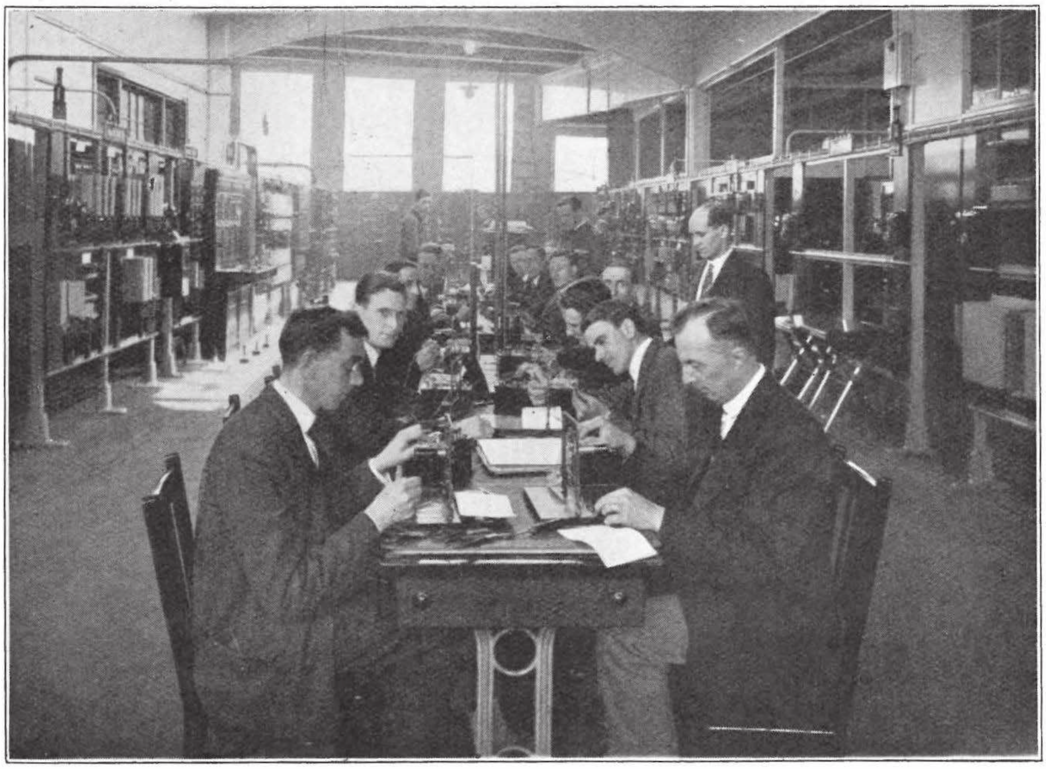


FIG. 5.—STUDENTS BEING TRAINED IN ADJUSTMENTS.

Fig. 7 shows a Lecture in progress. There are two Lecture Rooms, in one of which Lantern Equipment is available. In Fig. 7 near the door will be seen a small working model for the use of the Lecturer. It is frequently necessary whilst lecturing to illustrate a point by reference to working apparatus and the small model shown has been designed to illustrate a large variety of facilities. In connection with the daily lectures given at the Training School, arrangements are made for the demonstration of working apparatus in the Lecture Rooms. Directors, coders, senders and other types of equipment are brought into the room and electrically connected to the working equipment of the Demonstration Room. Sample apparatus boards also are demonstrated in the Lecture Room; these consist of apparatus mounted on boards painted black with prominent white lines connecting the apparatus in the front but actual wires at the back. By placing the correct electrical conditions on these boards certain features can be illustrated with more effect than by the drawing of sketches on a blackboard.

In connection with the study work of students, considerable attention is paid to the development of mental alertness and from time to time simple test papers are set. These afford a useful indication to the Instructors as to the effectiveness of their work, and as the setting of the test papers is done without the stiff and serious conditions of an examination, it has the effect of placing the students at their ease and encouraging them to answer the papers naturally. Another rather useful and interesting innovation is the distribution to the students of circuit diagrams known to contain errors. The students are requested to discover the errors and state what effect such errors would have on the actual working of the circuit. The theoretical and practical training afforded at the School is supplemented by the copious distribution of diagrams and descriptive letter press. These, together with the students' Note Books, remain their personal property.

As regards the practical training of the maintenance staff, samples of every piece of apparatus and type of relay are handed to each student, who dis-assembles, re-assembles and places on the apparatus the standard adjustment. The apparatus is repeatedly re-adjusted until the Instructor is satisfied that the student is a capable maintenance man as regards that particular item. The students are passed through a definite routine, which includes a couse of fault localisation, and at the end of the course an assessment of their progress is made. The courses vary from five weeks to 12 weeks in duration and it is planned to train and give lectures to 650 people per annum.

The work in the Circuit Laboratory consists in the carrying out of expert tests on apparatus and circuits submitted by the

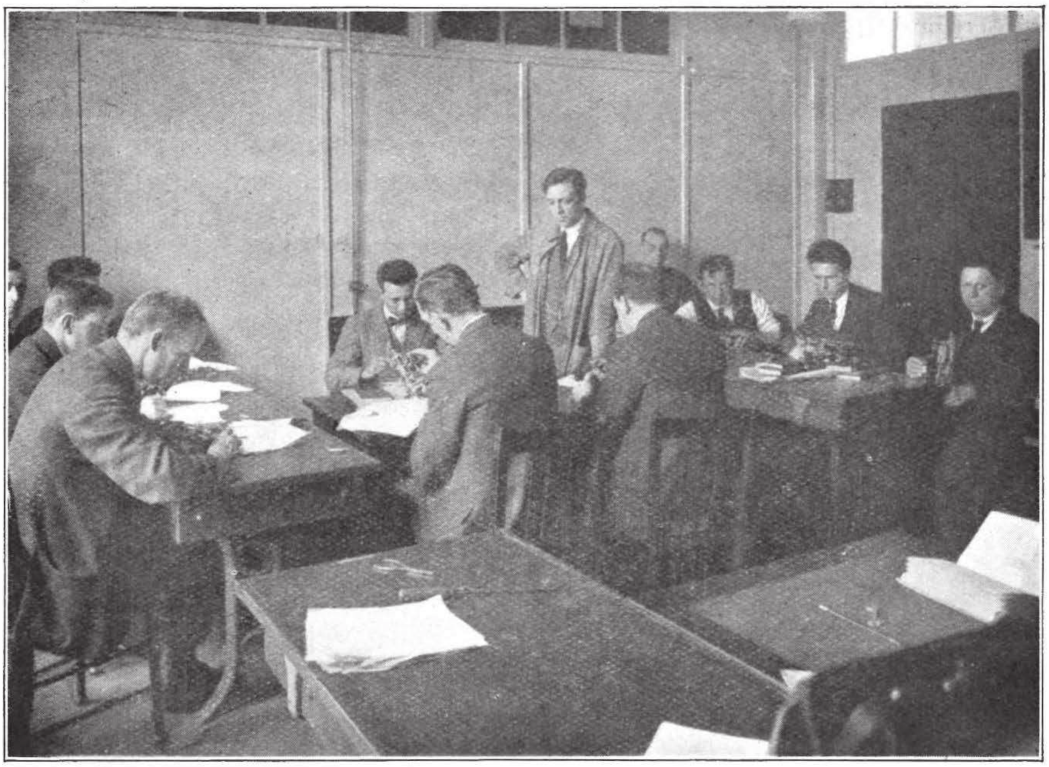


FIG. 6.—STUDENTS IN STUDY ROOM.

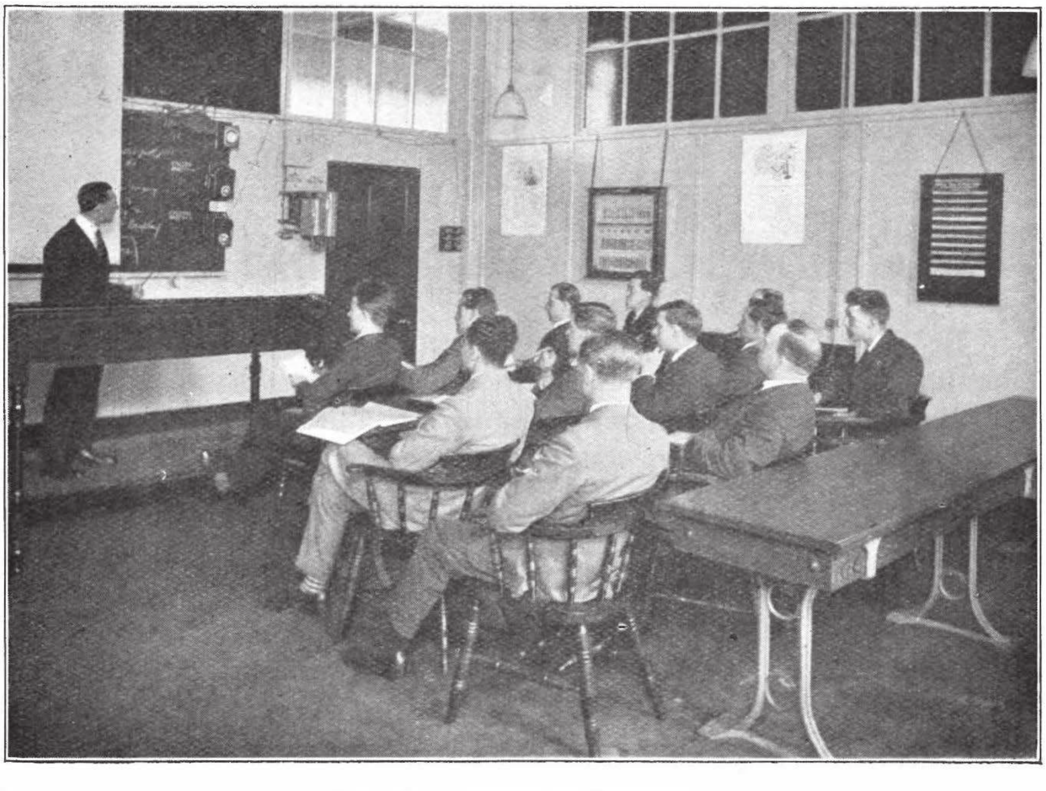


FIG. 7.—LECTURE IN PROGRESS.

different contractors. Although the bulk of the work performed in this department is done in conjunction with the London Equipment Committee, tests are also carried out in connection with the circuits designed by other Sections of the Engineer-in-Chief's Office, and the Circuit Laboratory is now an established part of the Engineer-in-Chief's circuit design work.

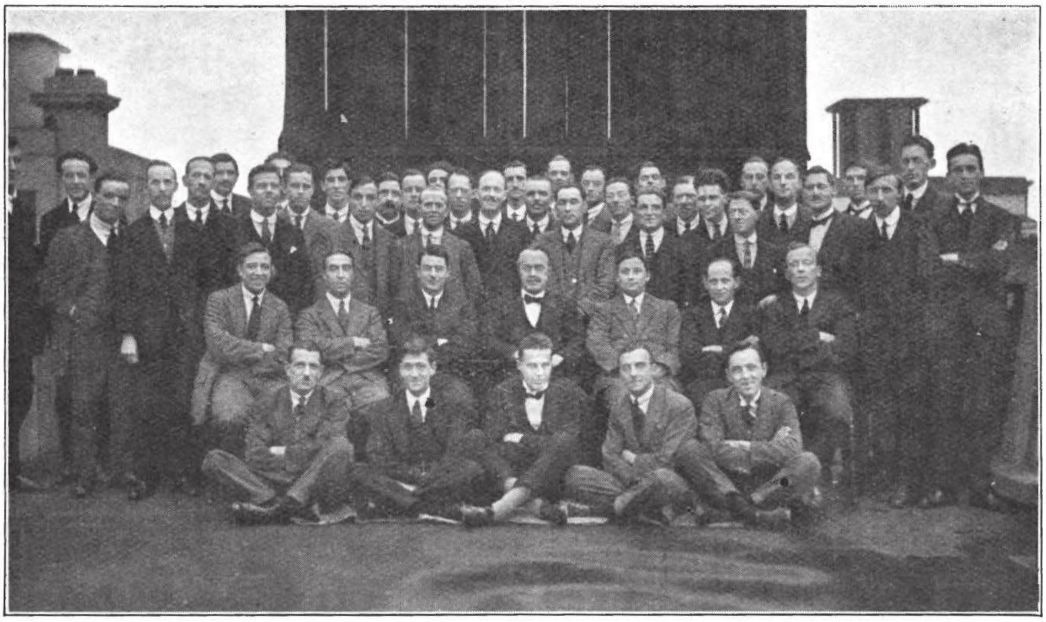


Fig. 8.—Staff of School and Circuit Laboratory with a Group of Students.

Fig. 8 shows the staff of the School and Circuit Laboratory with a group of students.

A MONSTER TELEPHONE BATTERY.

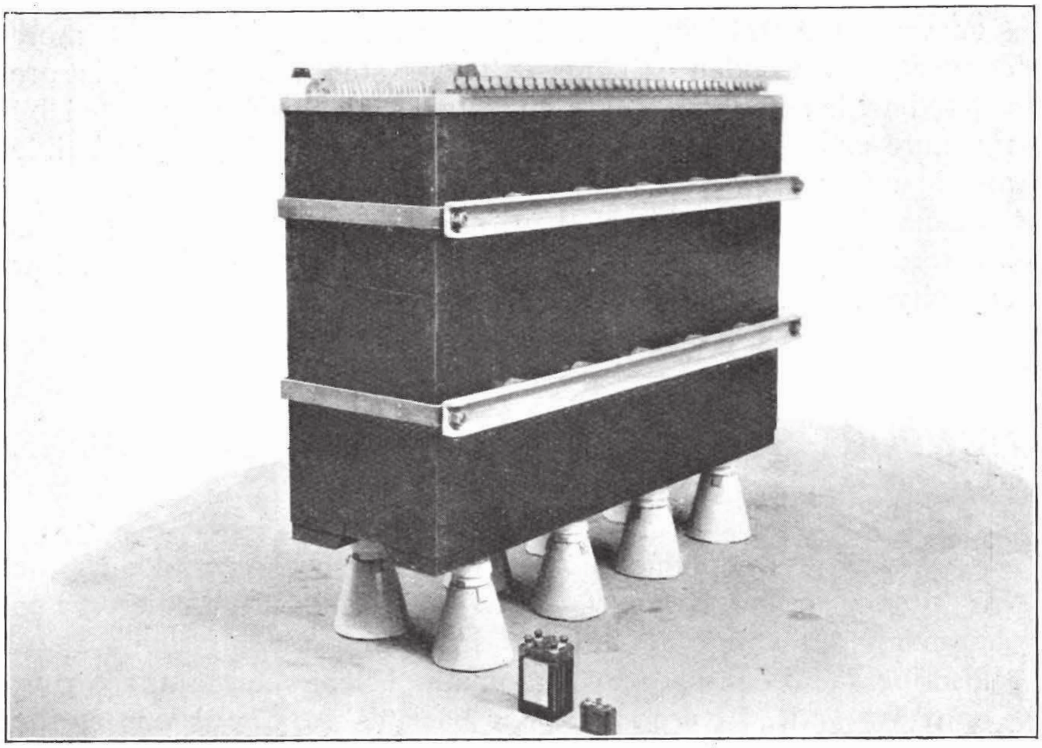
In connection with the Automatic Telephoning of Greater London, now in progress, there are being supplied by the Chloride Electrical Storage Company, Ltd., of Clifton Junction, near Manchester, four storage batteries of record size and capacity so far as Telephone Service is concerned.

There are four batteries in all, two of which will supply the current for operating the Holborn Mechanical Tandem Exchange, and the others that for working the Automatic Equipment in the Holborn Exchange proper. Both installations are in progress, the responsible contractors and manufacturers of the Strowger equipment being the Automatic Telephone Manufacturing Company, Liverpool.

In point of actual dimensions of individual cells those constituting the above batteries will be the largest yet installed in this country for telephone services.

The overall dimensions of each cell are: length, 5ft. 8ins.; width, 1ft. 8ins.; overall height, 5ft. There are 35 positive plates and the total weight per cell, including electrolyte, is 4,600 lbs., or over two tons. Overall plate dimensions are: height, 29ins.; width, 14ins.

The containers are of wood, lined with lead, and the positive and negative plates are separated by glass tube separators, all plates of common sign being burned to heavy lead connecting bars fitted with suitable terminal cups at the ends of each battery to which the main copper bus bars will be atttached.



ONE OF THE CELLS FOR THE HOLBORN EXCHANGE BATTERIES.

The positive plates are of pure lead, "Plante" type, and the negatives of box type.

The cell capacities are 8,400 A.h., discharging in 5 hours to 1.85 volts per cell, and 9,870 A.h. discharging in 9 hours to 1.83 volts per cell.

Taking into account the very small currents required to actuate individual telephone transmitters, these huge current values appear disproportionate, especially to readers familiar with the old magneto telephone system, in which a couple of Leclanche elements, or dry cells, located at the subscriber's premises, furnished all the necessary current for effective telephoning under that system.

It has to be borne in mind, however, that the ingenious electro-mechanism of the Automatic Telephone System which is being introduced into the service of Greater London telephone subscribers calls for the expenditure of electrical energy to actuate it, and although individual switches do not make any heavy demand upon the source of supply, the aggregate consumption when some thousands of people are telephoning or dialling simultaneously is fairly heavy, quite apart from the current flowing out over the lines to the subscribers' premises to energise their microphones during actual conversation.

The four batteries each comprise 25 special J.F.L.W. 35 cells answering to the above description, and a special feature, apart from their abnormal dimensions and capacities, is the use of stoneware pedestal supports, eight per cell, in place of the more conventional wooden stillage. These stoneware pedestals are capped with smaller oil-type insulators, which are unaffected by moisture or acid, the combination being practically indestructible and insuring high insulation and immunity from leakage.

Some idea of the size of these monster telephone storage cells is afforded by the illustration, which also depicts two familiar low capacity wireless batteries in the foreground.

NEWPORT STROWGER AUTOMATIC TELEPHONE AREA EXTENDED.

Automatic Telephone facilities have just been extended by the Post Office in the Newport (Mon.) area of South Wales. The Automatic Exchange at Newport itself now serving some 2,400 subscribers and equipped by Automatic Telephone Manufacturing Company, Ltd., Liverpool, as far back as 1915, was one of the earliest Strowger exchanges to be put into service in this country.

The original installation was completed soon after the outbreak of war and before the disorganisation caused by the subsequent demand for men and munitions held up the further development of the system.

The success of the original Newport installation has created the inevitable demand for equal facilities in outlying districts, and this is now being met by the opening of two new Strowger exchanges at Risca and Cwmbran respectively. These are satellite exchanges of Newport and will operate in conjunction with the Strowger equipment at the main exchange.

Risca is a town on the River Ebbw, 6½ miles N.W. of Newport. It has a population of 16,745. It is the centre of tinplate works, chemical works, and colleries.

Cwmbran, also an industrial centre with ironworks and collieries, is a village 6¾ miles from Newport.

Both installations are of the Rotary P.B.X. type, comprising single units, that at Risca being equipped with 57 subscribers and 3 coin-box lines, whilst the Cwmbran unit boasts 76 subscribers and 4 coin-box lines respectively.

Although the system is 4-digit in both cases the local line Switch Units are only equipped with Rotary Line Switches, Final Selectors and Repeaters, the 1st and 2nd Group Selectors being located at Newport Main Exchange. Thus in making a local call in either Risca or Cwmbran the route will be *via* the local Rotary Line Switch and Repeater to Newport, where, after passing through the 1st and 2nd Group Selectors and Main Exchange Repeater, it will be diverted back to the local Final Selector and there completed.

Subscribers' meters of the Booster battery type are provided, the calling subscriber's meter being operated only when the called subscriber answers. Ineffective calls are neither metered nor charged against the subscriber.

The coin-box lines have access to two special Repeaters in each exchange and the junctions from these Repeaters terminate on the Manual board at Newport, where an operator is in attendance to obtain the required number.

Risca has 6 outgoing and 11 incoming junctions, whilst Cwmbran is equipped with 8 outgoing and 12 incoming junctions. These are in addition to the two outgoing coin-box junctions previously referred to.

Following standard Strowger practice, the rotary line switches are mounted on two gates which may be swung outwards from the centre, allowing access to all the switchboard cabling. They are divided into four sections, each of 25 switches.

Above the line switches is mounted a power-connecting panel with alarm fuses, through which the current is fed to the switches. Over this again is a terminal assembly, where the outgoing primary trunks from the line switches are connected to the trunks to Repeaters. The incoming trunks and final selector connections are also made at this point. Four tag blocks above the terminal assembly serve as terminals for the lines to line switches, and mounted between them is a supervisory lamp strip for signalling faults.

On the Final Selector side of the two units are shelves, each with a capacity for 8 switches. The present equipment at Risca is 11 Final Selectors and 1 Test and offering Final Selector, whilst Cwmbran has 12 Final Selectors and 1 Test and offering Final Selector.

On the other shelves are mounted the Regular and Coin-box

Repeaters, together with the Howler Circuit Relay Group. To the left of each shelf is a fuse panel controlling the current supply to individual switches.

The banks of all Final Selectors are multipled together, thus allowing any Final Selector access to any line terminating on the banks.

Mounting plates above the Final Selectors carry miscellaneous relays and equipment.

The Strowger Automatic Telephone Exchange equipment for these typical small outlying exchanges is extremely compact, despite which it gives immediate access without error or delay to any other subscriber in the Newport area or *via* " Trunks " to any part of the Kingdom.

The completion of these Newport satellite exchanges marks another step in the progressive programme of Post Office automatic telephone development by which areas surrounding a central main Exchange will eventually enjoy the advantages of a full automatic service.

As in the case of the original Newport installation, the Strowger equipment for Risca and Cwmbran exchanges has been manufactured and installed for the Post Office by Automatic Telephone Manufacturing Co., Ltd., Liverpool.

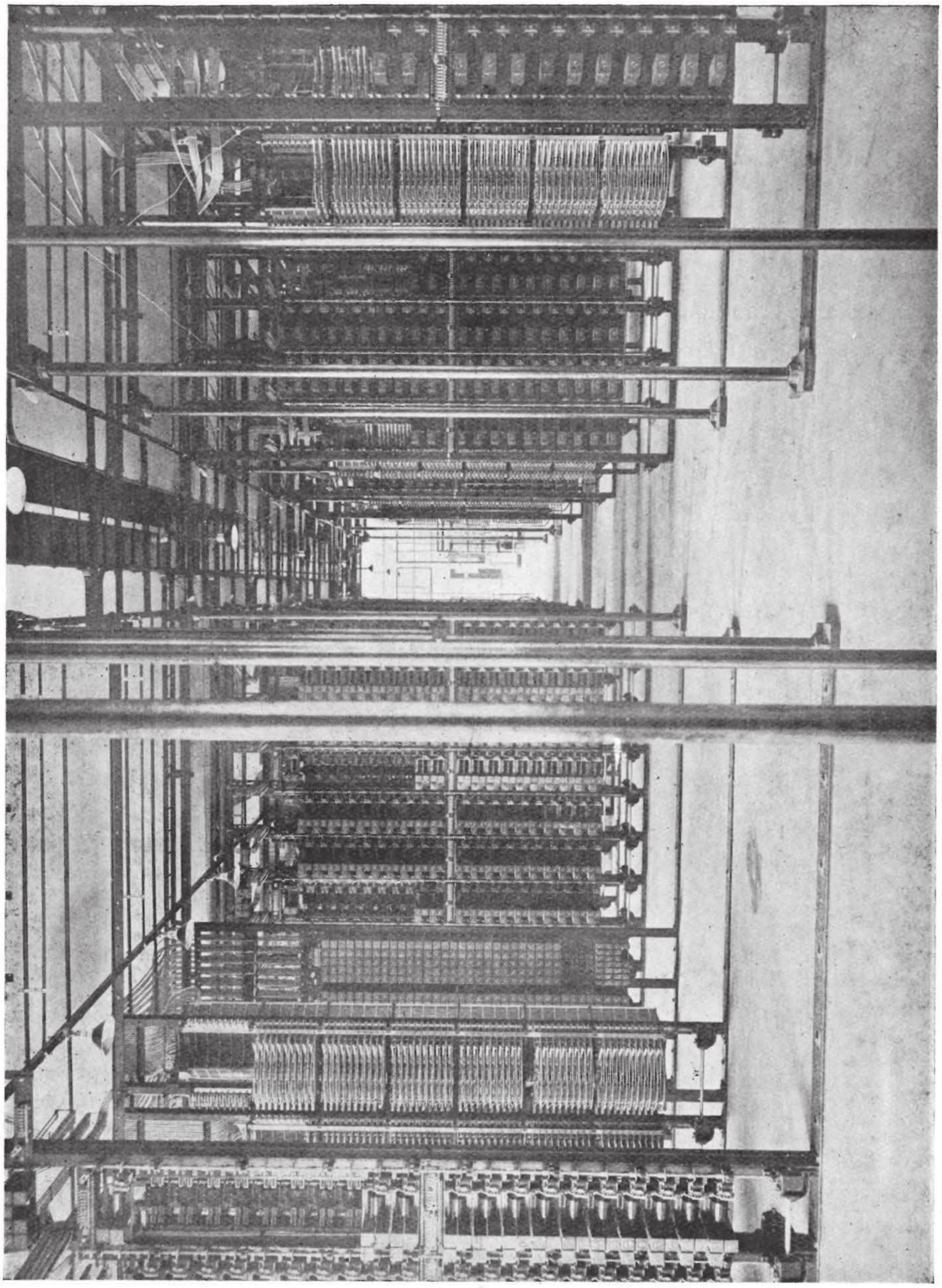
THE L.M. ERICSSON AUTOMATIC TELEPHONE SYSTEM.

THE following is a description of the Automatic Telephone System of the Swedish L.M. Ericsson, of Stockholm, designed to meet the needs of modern telephonic communication, with its involved requirements and often dense concentrations.

This system is of the power-driven type, employing connecting switches of 500 lines capacity; associated wiper sequence-switches mounted on bases which also carry the trunk relays; trunk register finders or alternatively register trunk finders, of sequence switch pattern; and register sets, which temporarily come into service for projecting a call.

All the three mentioned unit types, which together with relays may be said to constitute the system, are shaft driven and made readily demountable.

A salient feature is the arrangement of the multiple, which consists of bare wires arranged in vertical frames for twenty lines, twenty-five such frames being mounted radially in a rack, the whole of a height that all switches requiring access to the group of five hundred lines thus formed can embrace any required line upon its same stretch of bare wire multiple.



A View of an L.M. Ericsson Installation.

These multiple racks are of identical construction for all stages, *i.e.*, line finders, group selectors and connectors, so consequently all connecting switches are of similar design, varying only in minor detail.

To economise in height these switches are of dish formation operating in a horizontal plane, with a double movement of rotary and radial motion, the rotary movement first locating the required one of the twenty-five frames and the radial movement causing the brush carrier to travel along the multiple wires of this frame to a maximum depth of twenty lines.

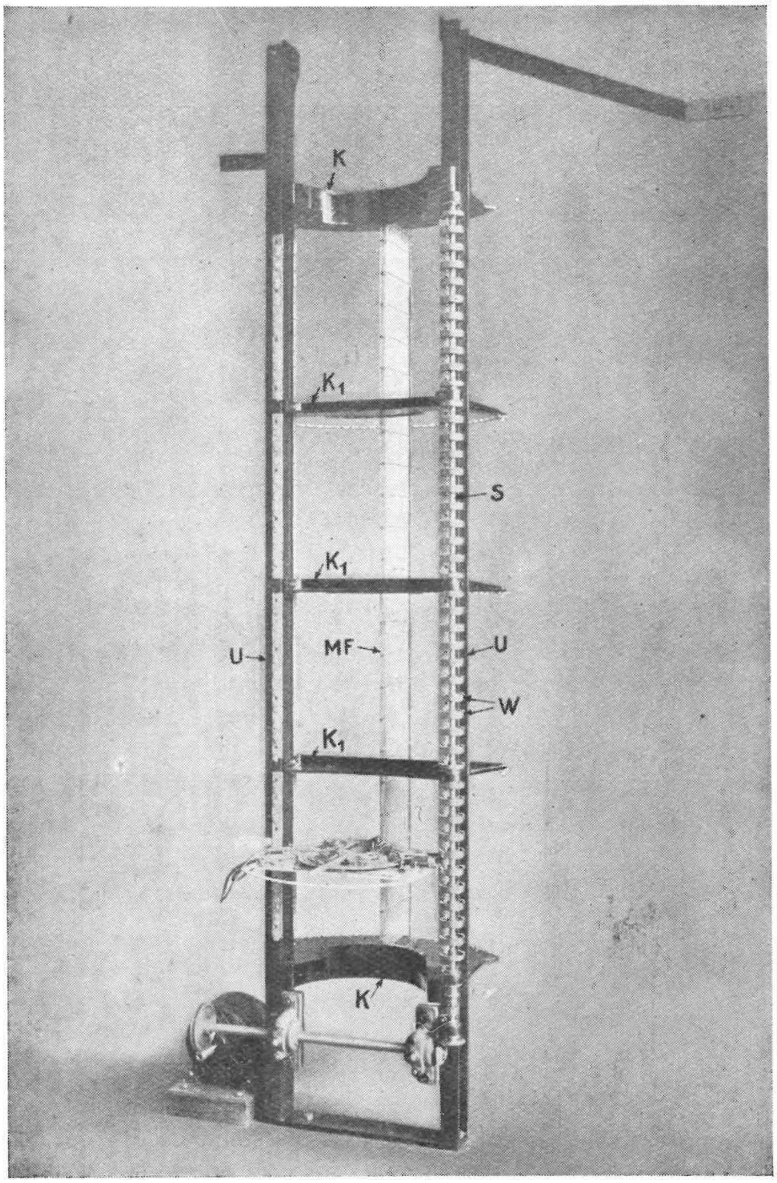


Fig. 1.—Selector Rack for 40 Selectors.

I.—Description of the Switching Apparatus.

A. The Selectors.

The selectors are mounted in racks accommodating 40, 50, 60 or 70 selectors. Fig. 1 shows a rack for 40 selectors. Such a rack consists of two vertical channel irons connected both at the top and bottom by means of the brackets K. Additional brackets K_1 are inserted for each group of 10 selectors.

On the insides of the channel irons are fastened metal strips with horizontal notches into which the selectors are slipped and locked in place.

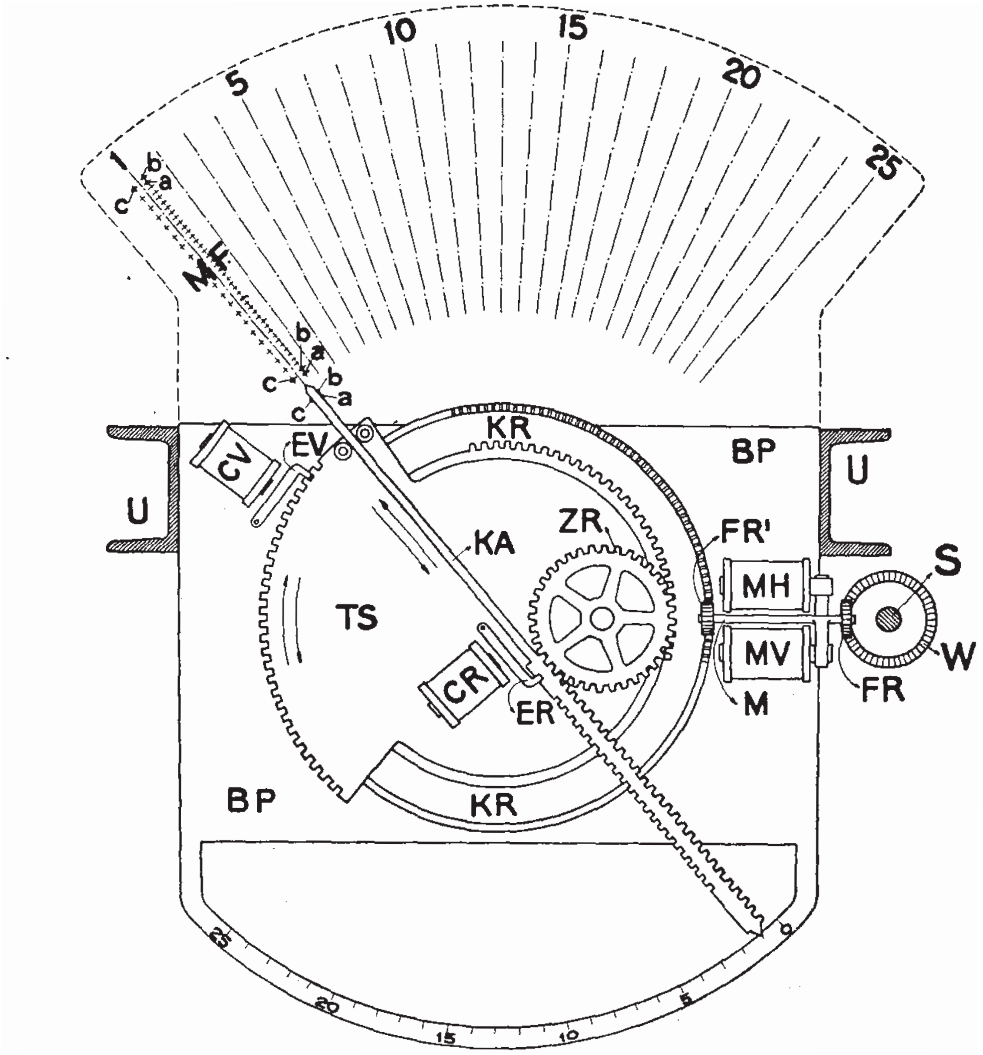


FIG. 2.—A 500 LINE SELECTOR PLAN.

Down the right side of the rack is the driving shaft, mounted in ball-bearings and furnished with double toothed drivers, W, one for each selector.

The multiple consists of 25 multiple frames MF (Fig. **1** shows such a frame in position) placed radially in relation to the selector's centre of rotation, as shown in Fig. **2**. Each multiple frame is composed of vertical bare wires for 20 lines, held by strips of insulating material.

Fig. **2** shows in outline a selector rack with one selector as seen from above. A connector is shown in Fig. **3**. The main components are:—

Base plate	BP
Magnet coupling	MH – MV
Rim gear wheel	KR
Rotary disc	TS
Locking magnet for the same	CV
Contact arm	KA
Locking magnet for the same	CR

The magnet coupling, mounted directly on the base, has two magnet coils MH and MV. The shaft M, carrying the toothed wheels FR and FR$_1$, is run through the armature, which is common to both coils. The armature can be attracted by either the coil MH, giving it an upward movement, or the coil MV, giving it a downward movement. These movements cause the toothed wheel to be brought against either the upper or the lower driver W, thereby giving the shaft M a rotary movement in either the one or the other direction.

The function of the rim KR is to convey the movement from the wheel FR$_1$ to the rotary disc and the contact arm. The teeth on its outer edge gear into the wheel FR$_1$ and those on its inner edge gear into the wheel ZR, which is pivoted on the rotary disc TS, and whose function is to convey movement to the contact arm. The rear part of the contact arm is formed into a rack geared to the wheel ZR (ZR consists actually of two wheels, pivoted on the same shaft, the under one being geared to the rim KR and the upper one to the rack on the contact arm).

Moveably mounted on the rotary disc TS is the contact arm KA, the front part of which is covered by an insulating sleeve of rectangular section, carrying the three selector contact springs, *a*, *b*, and *c*. The contact arm has two different movements, namely, a rotary movement, in which it follows the turning of the disc around its axis, and a radial movement, by which it moves into or out of a multiple frame.

The movements of a selector are controlled by means of the two locking or centering magnets CV and CR.

The magnet CV controls the rotary movement of a selector, its armature being shaped to a dog EV, which fits into notches on the rotary disc, thereby locking it. The notches are spaced so as to exactly conform to the position of the contact arm in relation to the multiple frames. In Fig. **2**, for example, the contact arm is centred exactly opposite frame number 1.

The magnet CR controls the radial movement by means of its armature, which forms the dog ER, whose function it is to centre and lock the contact arm. This it accomplishes by striking into notches on the contact arm, corresponding to the positions of the 20 lines of a multiple frame.

The magnets MH and MV are furnished with the necessary current through contacts located on the locking magnet armatures, when these latter are attracted. The two following cases can then occur:—

1. If the locking magnet CV is actuated, the selector is released for rotation and the rotary disc, together with the contact arm, will start turning. This movement continues until the circuit through CV is broken and the dog engages a notch, thus locking the rotary disc, the current supply to the magnet coupling being simultaneously cut off. A left- or right-handed rotary movement is obtained depending on which of the magnet coupling coils MH or MV is energised.

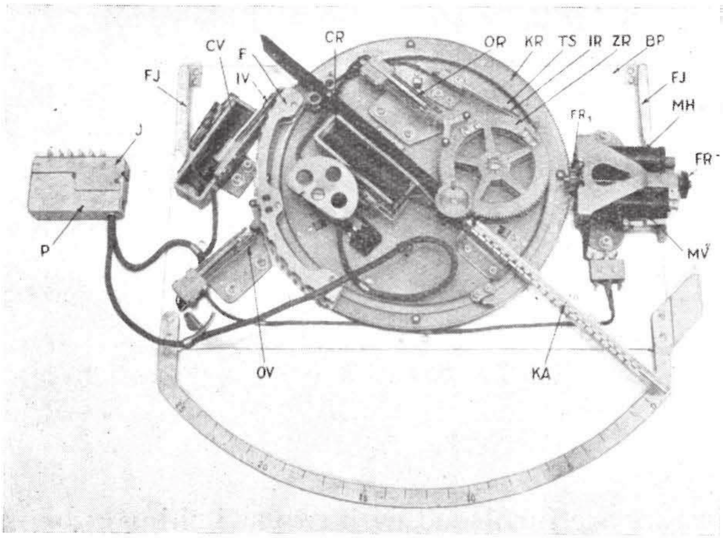


Fig. 3.—A Connector.

2. If the locking magnet CR is actuated the contact arm is released for radial movement. This movement continues until the circuit through CR is broken and the dog engages a notch on the contact arm, thus locking the same, the supply of current to the magnet coupling being simultaneously cut off. The contact arm is either thrust into or withdrawn from a multiple frame, depending on which one of the magnet coupling coils MH or MV is energised.

As has already been mentioned, the three different types of selectors used in this system, *i.e.*, line finders, group selectors, and connectors, are mainly of the same construction. The details in which they differ are as follows:—

Each line finder is provided with a special test spring, mounted on the rotary disc (does not occur in Fig. **3**, which shows a connector), by means of which that multiple frame is found, in which an incoming call is located. The vertical front bars of the multiple frames in the line finder racks are, for this purpose, used as test bars, with which this test spring comes into contact during the line finder's rotary movement.

Group selectors and connectors have always a definite starting position for the rotary movement. They are provided with a cam plate F, mounted on the rotary disc, which alternately closes and opens a group of switching springs IV, thus sending impulses back to the register.

The connectors are further provided with a switching group, IR, for the sending of impulses to the register when the contact arm is moving into a multiple frame. This switching group is actuated by means of a cam wheel, mounted under the toothed wheel ZR on the same shaft.

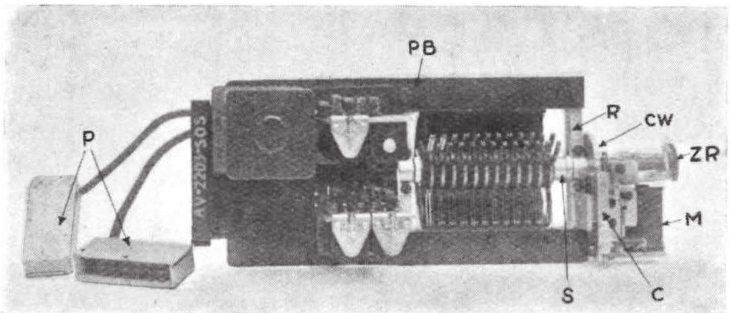


FIG. **4**.—SEQUENCE SWITCH.

All selectors are furnished with two switching groups, OV and OR, mechanically actuated in the extreme positions, one of their functions being to reverse the movements. OV reverses the rotary movement and OR the radial movement.

The connecting of a selector's wiring to the trunk lines is accomplished by means of an 18-point plug P, fitting into a corresponding jack J, mounted on the rack.

After being pushed into place in the rack, the selector is firmly locked in position by means of the two springs FJ.

B. The Sequence Switches.

Each selector is furnished with a sequence switch and relays, the appearance of which is shown in Fig. **4**. The contact bank consists of circular segments (the length of the arc being $\frac{1}{3}$ of a full circle) in which metal contacts are embedded. Each segment has two rows of metal contacts, and a maximum number of 13 segments can be screwed upon a frame R, which, in turn, is screwed to a second framework PB. This framework PB acts also as a support for the trunk relays.

As a sequence switch of this type has 12 positions and 13 rows of double contacts, it follows that 12 × 13 = 156 different contact combinations are possible, but additional combinations can be obtained by making the bank contacts of different widths, so as to extend over more than one contact position.

The sequence switches are power driven in the same manner as the selectors. M is the magnet coupling, with the toothed wheel ZR pivoted on its armature. The attracting of this armature causes ZR to engage a driving wheel mounted on the common driving shaft, the rotary movement being transmitted to the shaft S and the wiper arms.

Each sequence switch is furnished with an electrically controlled centering device, consisting of a cam wheel, CW, and the switching group C. Its function is to control the movements of the wiper arms by keeping the circuit closed through the centering spring until the wiper arms have reached the exact desired position.

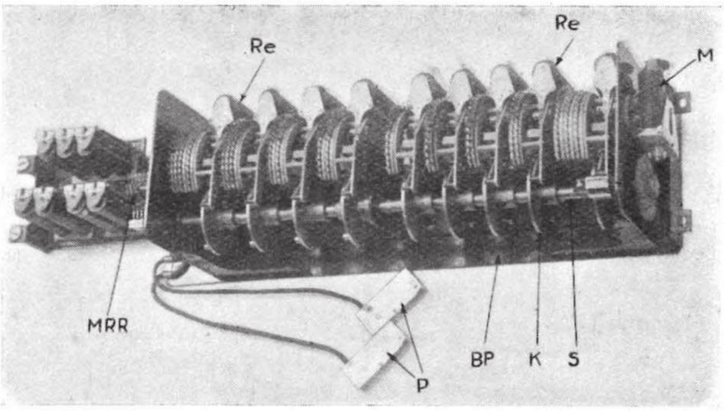


FIG. 5.—COMPLETE REGISTER SET FOR A 10,000 LINE SYSTEM.

Sequence switches are connected to the trunk lines by exactly the same methods as selectors, *i.e.*, by means of plugs P to jacks, which are mounted on the racks.

The sequence switches are mounted on both sides of the rack, each side or panel accommodating 20 switches, with their fuses and alarm devices.

C. The Register Sets.

A register set is shown in Fig. 5, the more important components being:—

The Base	BP
The Register Units	Re

The Restoring Mechanism, consisting of :—

A Magnet Coupling	M
A Shaft S with discs	K
A Sequence Switch	MRR

The relays with which a register set is equipped are mounted on the base BP, as shown at extreme left in Fig. **5**.

A register unit—shown in Fig. **6**—is a step-by-step selector. The bank of contacts consists of circular segments of insulation (extending over slightly more than half a circle) in which the metal contacts are secured. The wiper arms are mounted on the shaft S, which also carries the ratchet wheel SW and the restoring arm RA. A register unit has 27 contact positions, *i.e.*, the starting position 0, 25 positions from 1 to 25, and one extra position, 26.

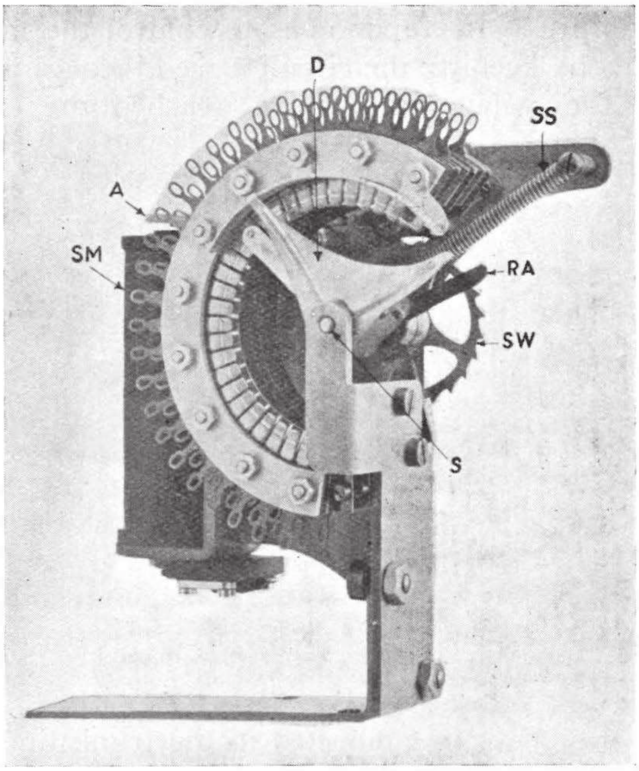


Fig. **6**.—Register Unit.

The ratchet device of the register unit consists of a magnet coil SM and its armature A. The armature actuates an escapement lever (not visible in the illustration) which, in turn, acts as a releasing mechanism for the ratchet wheel SW.

One end of the coil-spring SS is fastened to the frame and the other encircles the shaft S.

This spring tends to rotate the shaft and wiper arms, which movement, however, is counteracted by the escapement lever, which engages the ratchet wheel SW. Should the magnet coil SM be energised its armature will be attracted and the lever will release the wheel, allowing the wipers to advance one step. A renewed breaking of the current will readjust the lever, allowing the wipers to advance one more step. The wipers are thus advanced two steps for each full impulse (*i.e.*, one closing and one breaking of the circuit).

D is an indicator, which shows the position occupied by the wipers.

The register units forming part of a register set are mounted on the base BP (Fig. **5**).

The shaft S with the discs K is made to rotate when the restoring magnet coupling is brought to engage the vertical driver shaft. The discs K are provided with studs which operate the restoring arms RA of the register units, thus restoring the wiper arms to the starting position, 0.

Register sets are also removable in the same way as selectors and sequence switches, *i.e.*, by means of plugs fitting into jacks mounted on the racks.

The register sets are mounted on either one- or two-sided racks, with 10 to 12 sets to each panel.

D. *The Relays.*

The relays used in an automatic exchange are of an improved type, eliminating all internal connections, all switching group and coil connections being carried out to soldering tabs. The advantage of being able to remove and replace coils and switching groups is hereby gained. The relay armatures have been redesigned so as to make them more sensitive and quick-acting. Special pains have been taken to obtain a correctly balanced pressure for the contact points.

II.—THE BUILDING UP OF THE SYSTEM.

A.—The extending of calls to the group selectors, in the Ericsson automatic system, is accomplished by means of line finders. The Subscribers' lines are brought together in groups of 500. Every such group is connected to the multiple in a line finder rack. The number of line finders necessary for 500 lines depends on the traffic (*i.e.*, number and average duration of calls during the busy hour) and usually varies between 20 and 50.

B.—Each line finder is associated with a group selector, as shown in Fig. **7**, LF signifying a line finder and GS a group selector. Should 40 line finders be required, the corresponding group selector rack will also contain 40 group selectors. Trunks lead from the multiple frames in the group selector rack to the connectors or to further group selectors.

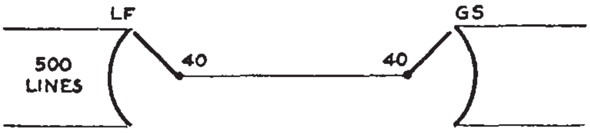


FIG. 7.—LINE FINDER AND GROUP SELECTOR.

If the full capacity of the twenty-five multiple frames for a group selector rack is utilised for trunks to connectors, a capacity of 25 × 500 = 12,500 lines is obtained. For practical reasons, however, it is not customary to use more than the first 20 frames for this purpose, the remaining 5 (21 to 25) being used for special lines.

A capacity of 20 × 50 = 10,000 lines is thus reached by the use of only one group selector, as shown in Fig. **8**.

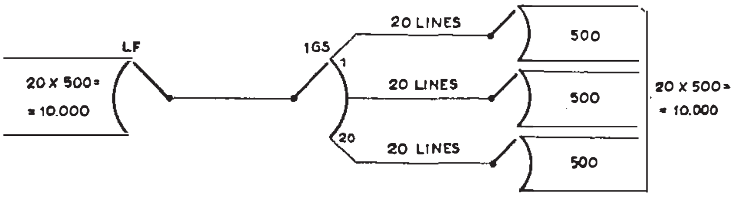


FIG. 8.—SCHEMATIC DIAGRAM FOR A 10,000 LINE SYSTEM.

The group selectors in a 10,000 line plant direct the connecting in of the desired 500-group by means of the rotary movement, while the radial movement is utilised to search out a disengaged connector.

C.—The connector makes the final connection to the desired number. The group of 20 which contains the desired number is sought out by means of the selectors' rotary movement, and the final connection is accomplished by means of the radial movement.

A connector multiple contains 500 lines, similar to the line finder multiple. Each group of 500 lines, therefore, has its connector rack, containing a certain number of connectors, their number depending on the intensity of traffic.

Fig. **9** shows the method of numbering the multiple frames in a group selector rack for a 10,000-line plant, while Fig. **10** shows how connector multiples are numbered.

Each group of 1,000 occupies 2 frames in the group selector multiple, the first containing the 5 lower hundreds—from 0 to 4, and the second containing the 5 higher hundreds, from 5 to 9.

D.—The capacity can be increased to 25 × 20 × 500 = 250,000 by adding one more group selector, as shown in Fig. **11**.

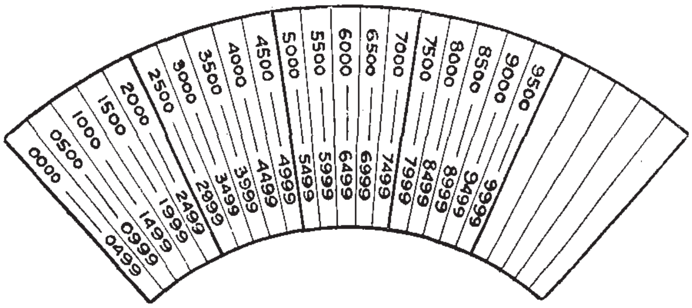


FIG. **9**.—NUMBERING OF MULTIPLE IN A GROUP SELECTOR RACK.

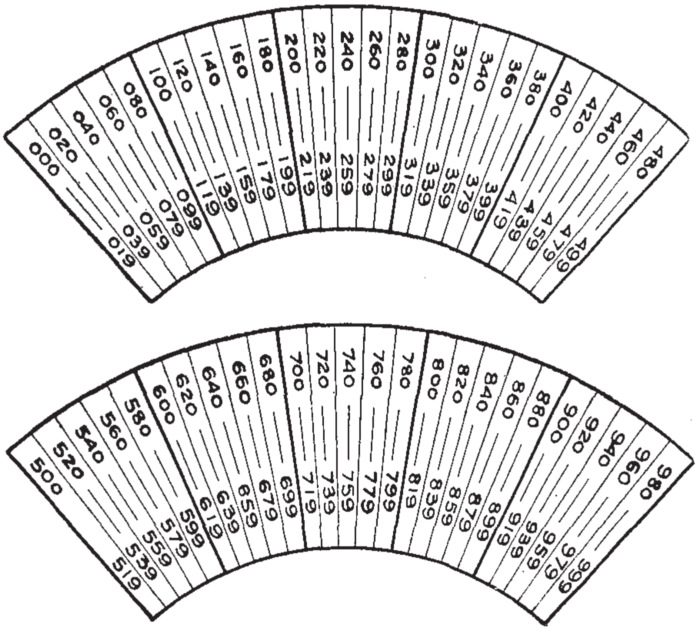


FIG. **10**.—NUMBERING OF MULTIPLE IN A CONNECTOR RACK.

Trunks are carried from the first group selectors 1 GS to 25 ten thousands groups. These trunks end in second group selectors 2 GS, the multiples of which are trunked to the connectors C of the respective 500 hundreds groups.

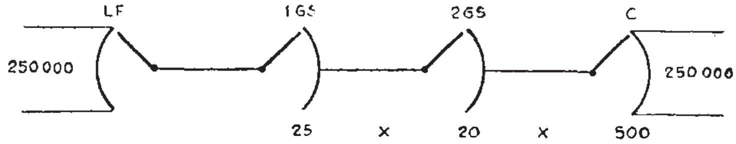


FIG. **11**.—SCHEMATIC DIAGRAM FOR A 250,000 LINE SYSTEM.

E.—Another system, in which either one or two group selectors are used to complete the connections, is applicable to plants of from 10,000 to 60,000 lines. A schematic diagram of this system, for a plant of 30,000 lines, is shown in Fig. **12**.

The 30,000 lines are grouped in 3 ten thousands. The traffic between subscribers whose numbers are within the same ten thousands group is handled by one group selector 1 GS, since the multiple frames of the first group selector rack contain trunk lines to the 20 five hundreds corresponding to their own 10,000 group. Trunk lines from the multiple frames 21 to 25 proceed to the second group selector 2 GS, the multiples of which are in turn trunked to connectors.

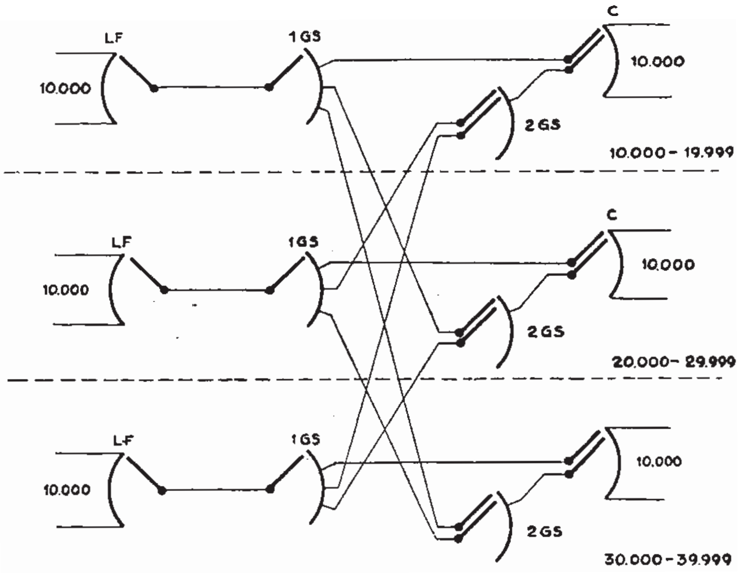


FIG. 12.—SCHEMATIC DIAGRAM FOR A 30,000 LINE SYSTEM.

Thus, a capacity of 10,000 + (5 × 10,000) = 60,000 is reached by this system when all the multiple frames of the first group selectors are utilised.

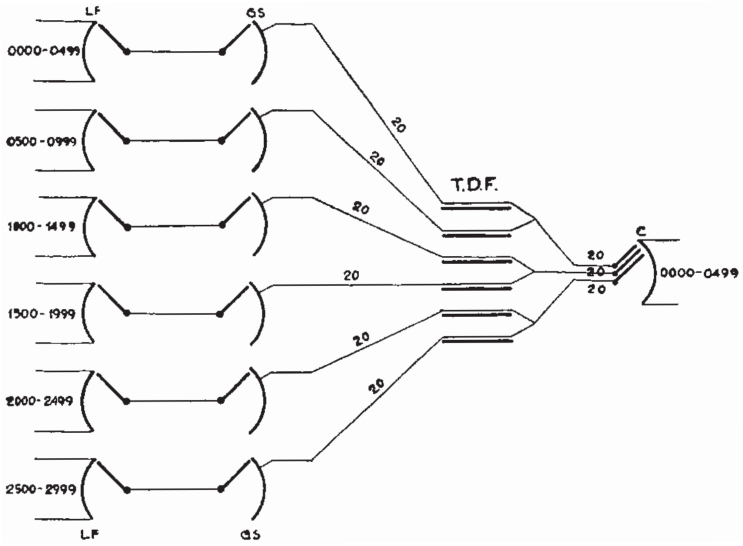


FIG. 13.—CONNECTION OF GROUP SELECTORS TO T.D.F.

F.—The connecting in parallel of the group selectors' multiples, and the connecting of the cables to the connectors is done in a traffic distributing frame. These frames are composed of two vertical angle irons furnished with tab strips to which the cable wires coming from the group selectors' multiple frames are connected and coupled in parallel so as to obtain an even distribution of connectors in relation to the amount of traffic. An example is illustrated in Fig. **13**. LF and GS are line finder and group selector racks for 6 five hundreds groups. Trunking to the traffic distributing frame is shown from the first multiple frame only, corresponding to the five hundreds group 0000 to 0499. Thus a 20-line cable is led from frame No. 1 in each group selector frame to the T.D.F. Suppose that traffic conditions necessitate the use of 60 connectors for 500 lines; the distribution can then be arranged as shown in Fig. **13**, for example, by parallel coupling the multiples in pairs, each pair with 20 trunk lines to the connector rack in question.

G. Connecting of the Register Sets.

When a line finder is connected to a subscribers line, a register set must also be connected for the purpose of directing the movements of the group selectors and connectors. Consequently, the register is placed between the line finder and group selector, as shown in Fig. **14**.

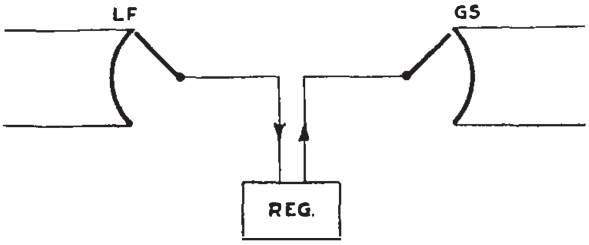


FIG. **14**.—SCHEMATIC DIAGRAM FOR LINE FINDER, SELECTOR AND REGISTER.

In view of the fact that a register set is engaged only as long as it takes the subscriber to dial the desired number and for the group selectors and connectors to move to their respective positions, while line finders, group selectors, and connectors, on the contrary, are engaged as long as the conversation lasts, it is easily understood that it would be highly uneconomical to provide a register set for each individual line finder, especially as they are comparatively expensive and bulky devices. For this reason, only a certain number are allotted to each group of line finders, the number being determined by traffic conditions. Special selectors are used for connecting the register sets to the line finders. Two different principles can here be applied, clearly illustrated in Figs. **15** and **16**.

In Fig. **15** the connecting is accomplished by means of so-called register trunk finders. Each register set is furnished with a register trunk finder (the construction of which corresponds to that of a sequence switch) accommodating 35 lines.

In this case, therefore, the line finders will form groups of 35. To each such group is allotted a certain number of register sets (6 to 9, depending on the traffic). A call entering such a group sets all the register trunk finders RS belonging to disengaged register sets in motion, and the one that first finds the calling line finder LF is connected.

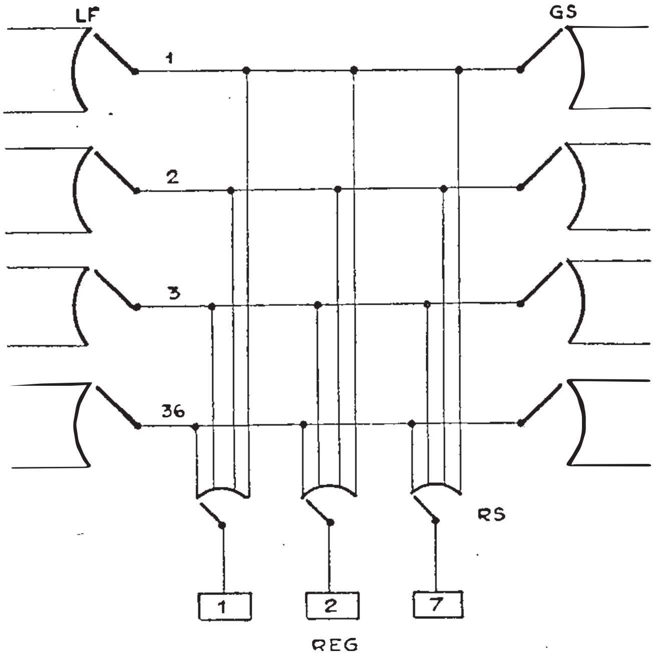


FIG. **15**.—SCHEMATIC DIAGRAM FOR TRUNK REGISTER FINDERS.

In Fig. **16** the register sets are connected by means of trunk register finders RV, of which one is allotted to each line finder LF. The contact banks of these finders—consisting of 20 contact positions—are coupled in parallel and connected to 20 register sets. The number of line finders LF which can be connected to a group of 20 register sets depends on traffic conditions. (One group of 20 sets can, as a rule, be connected to the line finders for 3 or 4 five hundred groups).

III.—FUNCTIONING OF REGISTER SET.

The mechanical construction of a register set has already been described under II—C. When considering its functions, a register set may be divided in two parts, namely, the registering part, which receives and "registers" the numbers dialled from the subscriber's telephone (or, in the case of a semi-automatic exchange, the numbers called from the operator's keyboard), and the controlling part, which directs the proper setting of the group selectors and connectors.

The schematic diagram of a register set for a plant with subscribers' numbers of four digits (0000 to 9999) is shown in Fig. **17**.

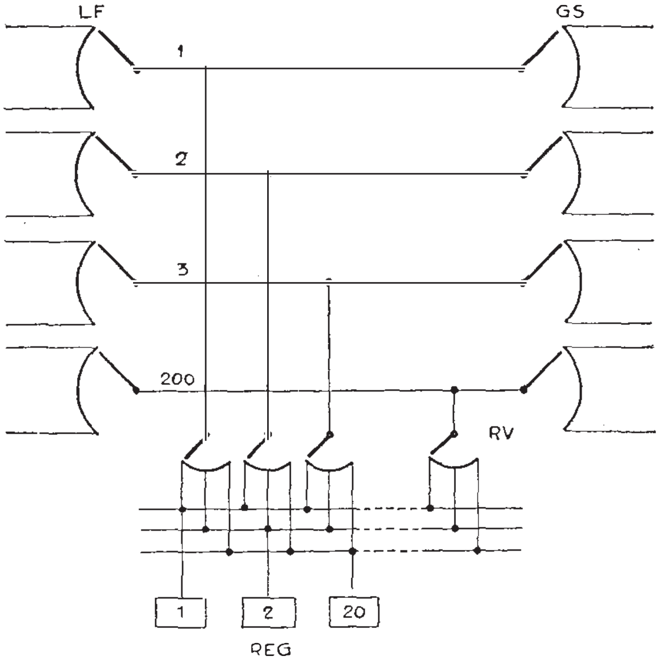


Fig. **16**.—Schematic Circuit for Register Trunk Finders.

A. Registering Part of the Register Set.

That portion of the register set which registers the numbers consists of:—

The Impulse Relay R_1.

The main function of this relay is to receive the impulses which are sent out by means of the subscriber's dial D. Simultaneously with the connecting of a register set to a subscriber's line, a circuit from earth over the subscriber's line and telephone, and through the impulse relay R_1, to battery, is closed, resulting in the actuation of the relay R_1. The dialling of a digit creates a train of circuit breaks or impulses, causing the relay R_1 to be released as many times as the circuit has been interrupted in the dial. (The number of circuit breaks corresponds in this case to the dialled digit. The figure 1 will cause the circuit to be interrupted once, the figure 2 twice, etc., and the figure 0, lastly, will cause the circuit to be interrupted 10 times).

The Restoring Relay R_2.

The function of relay R_2 is to restore the register to normal after a connection is completed. This relay is constructed so as to be slow-releasing only. It is attracted through the contact (*a*) in the relay R_1 at the same moment that the register is connected to a subscriber's line, and retains this position until the connection is completed. Owing to its slow releasing, relay R_2 remains attracted during the impulsing of relay R_1.

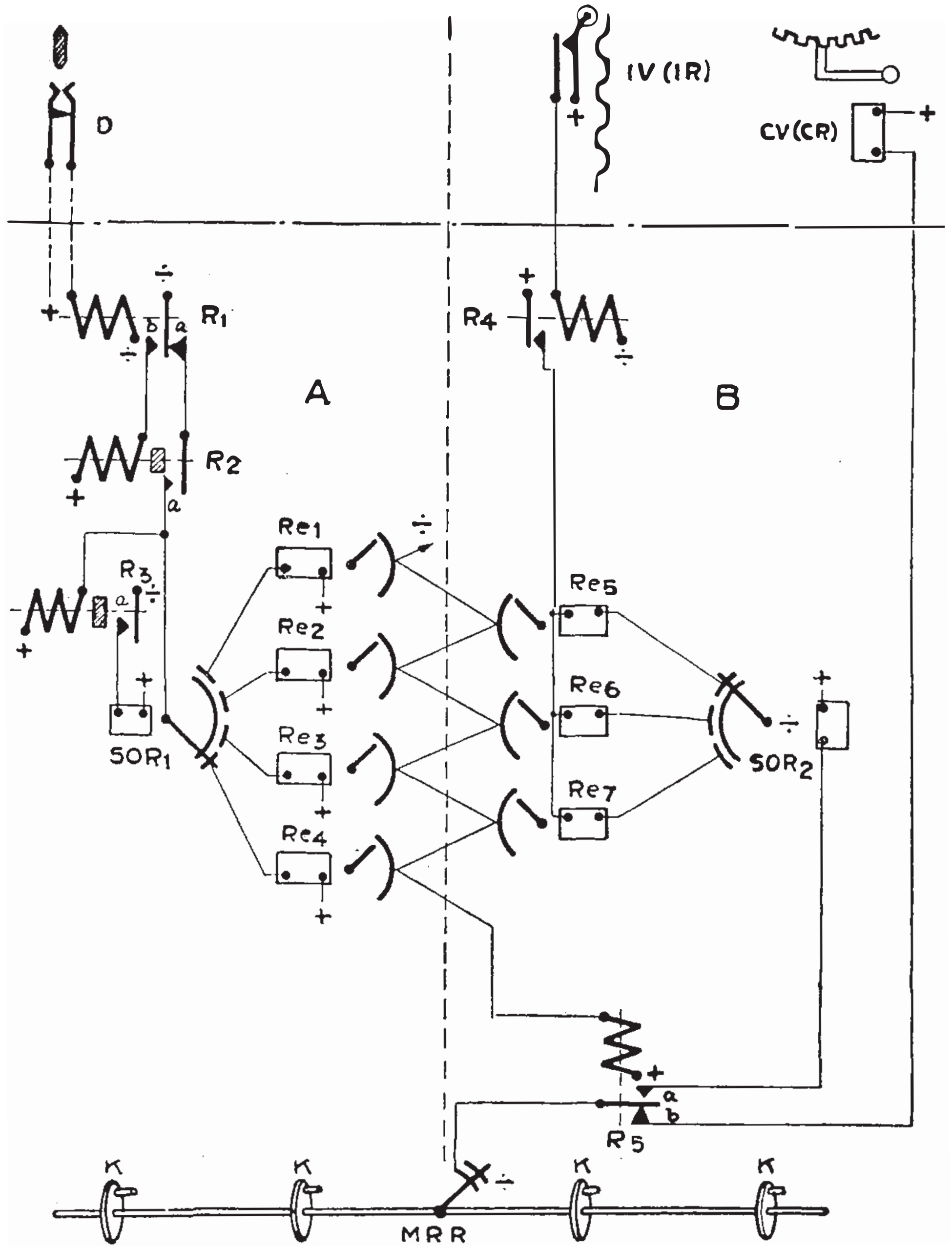


Fig. 17.—Schematic Diagram of Register.

The Controlling Relay R_3.

The relay R_3 controls the movements of the control switch SOR_1. It is a slow acting relay similar in design to R_2, and is, for this reason, attracted once for each train of impulses sent, that is, once for each figure dialled.

The Control Switch SOR_1.

This apparatus is similar in construction to a register unit, described under II—C, and its function is the successive connecting in of the units Re_1 to Re_4. Its magnet is energized over a contact in the controlling relay R_3.

The Registering Units Re_1 *to* Re_4.

The object of these units is to register the dialled numbers. They are successively connected in by the controlling switch and take the positions which correspond to the dialled numbers.

Re_1 is in circuit when the thousands digit is dialled.
Re_2 is in circuit when the hundreds digit is dialled.
Re_3 is in circuit when the tens digit is dialled.
Re_4 is in circuit when the units digit is dialled.

B. Controlling Part of the Register Set.

This part of the register set is composed of—

The Revertive Impulse Relay R_4.

The function of this relay is to receive the impulses sent out by the group selectors during their rotary movement and by the connectors during their rotary and radial movements, and repeat them to the controlling units Re_5 to Re_7. These impulses are generated over the impulse contact IV (IR), and correspond in number to the number of steps which the selector and connector movements have advanced.

The Stop Relay Re_5.

The relay R_5 cuts off the starting current to the group selectors and the connectors and serves also to close the circuit to the magnet of the control switch SOR_2.

The Control Switch SOR_2.

The function of this control switch is to successively connect in the controlling units Re_5 to Re_7.

The Controlling Units Re_5 *to* Re_7.

The controlling unit Re_5 is set by the rotary movement of the group selector.

The controlling unit Re_6 is set by the rotary movement of the connector.

The controlling unit Re_7 is set by the radial movement of the connector.

These controlling units, which receive their impulses from the revertive impulse relay R_4, exactly follow the selector movements, for example, when the rotary movement of a group selector has advanced 11 steps, the controlling unit Re_5 has also been advanced 11 steps, etc.

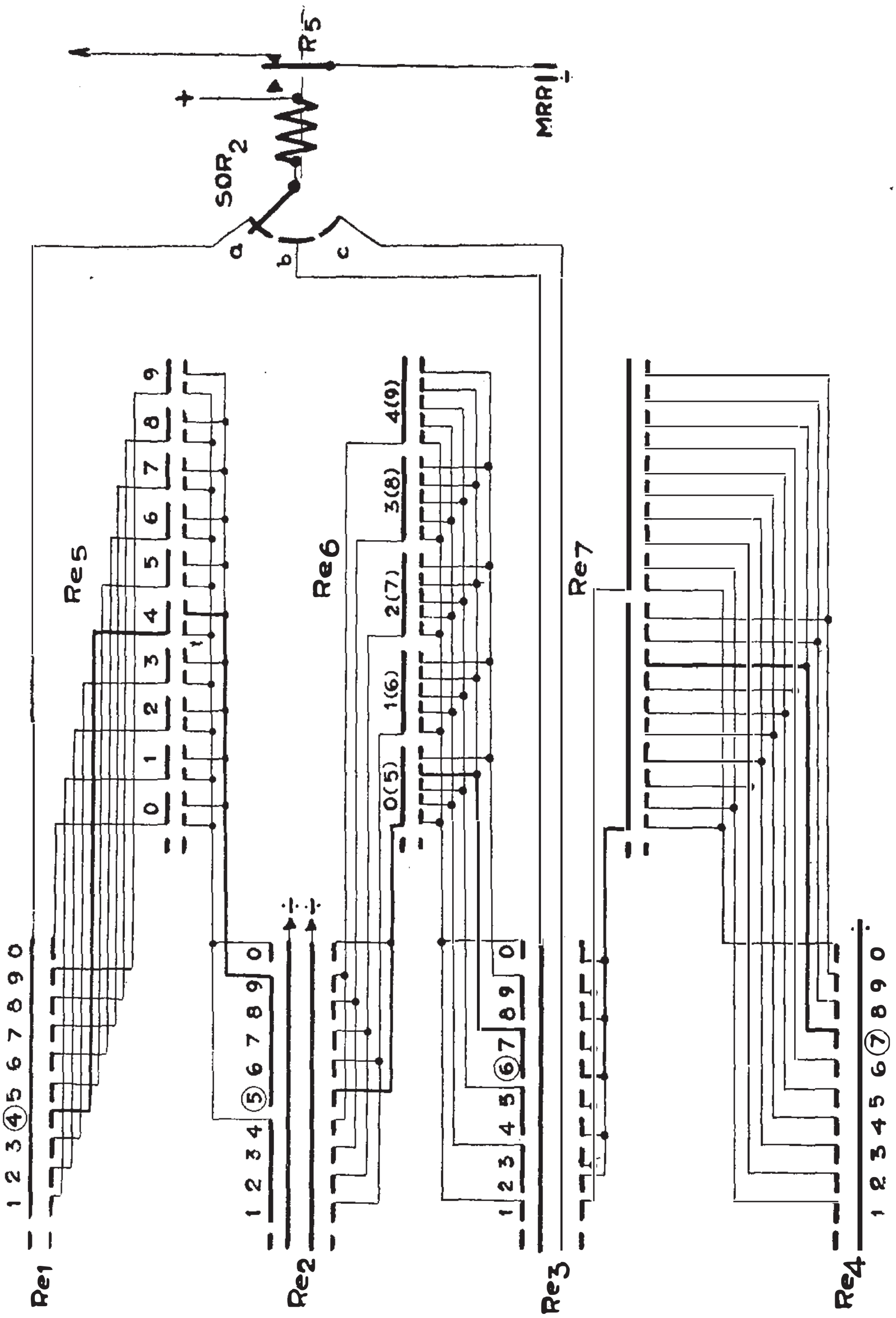


FIG. 18.—CONNECTIONS BETWEEN STORING AND CONTROLLING REGISTER UNITS.

The restoring mechanism with discs K has a sequence switch MRR connected to its shaft, one of whose functions is to connect in the battery for starting the group selectors and connectors, The setting of the group selectors and connectors is accomplished by means of so-called revertive impulse control. When a sufficient number of digits has been dialled and registered by the registering units Re_1 to Re_4 (the two first digits for a four-digit numbering system), the sequence switch MRR is reset so that battery is connected in for starting the group selector. The centering magnet for rotary motion CV is energized (over a special relay, which for the sake of simplicity, is omitted in Fig. **17**), whereby its armature releases the rotary disc and simultaneously closes the circuit to the magnet coupling. Impulses are sent out to the register, while the group selector is rotating, whereby the controlling unit Re_5 is properly set. When the selector movement has advanced a number of steps corresponding to the first two figures in the dialled number (the thousands and hundreds figures), a circuit is closed over the registering units Re_1—Re_5—Re_2 through the relay R_5, which hereby attracts its armature and breaks the selector-starting current at the contact in R_5.

The principle of setting for the connectors is the same as for the group selectors. The setting of a group selector, as has already been mentioned, is determined by the first two digits of a four figure number, the first digit determining the thousands group, while the second digit determines whether the switching shall be directed to a five hundreds group of a low or high hundreds figure. This principle of setting is also made evident by the numbering of the group selector multiples as shown in Fig. **9**.

The rotary setting of a connector is determined by the hundreds and tens figures (see Fig. 10). It may here be noted, that the low hundreds figures 0, 1, 2, 3 and 4 are equivalent to the high hundreds figures 5, 6, 7, 8 and 9.

The radial setting of a connector, lastly, is determined by the tens and units figures.

IV.—CONNECTING A CALLING TO A CALLED SUBSCRIBER.

The process of establishing a speaking circuit between two subscribers is shortly as follows:—

A. The call is connected to an idle line finder.
B. The call is connected through the line finder and a register selector (or register finder) to a disengaged register set.
C. The number called is registered within the register set.
D. The group selector is set to its rotary position.
E. The contact arm of the group selector enters the multiple, hunting an idle connector.
F. The connector is set to its rotary position.
G. The connector is set radially.

H. The register set is restored to normal after having completed its function.

I. The connector is testing to see whether the desired number is free.

K. A ringing current is sent out to the called number.

L. The called subscriber answers, thereby breaking the ringing circuit.

M. The selectors are restored to normal when the call is cleared, the call being recorded on the calling subscriber's service meter.

Description of Circuits.

Fig. **19** depicts how a line finder seeks out a calling subscriber.

A. Section I. Subscriber's connector multiple.
,, II. Line and cut-off relay and meter circuit.
,, III. Group relay for the 20 lines in a multiple frame.
,, IV. Subscriber's line-finder multiple.
,, V. Starting distributor.
,, VI. Line finder.
,, VII. Sequence switch.
,, VIII. Relevant circuit on group selector.

When a subscriber calls, the line relay LR actuating, causes

(1) The actuation of group relay LGR.

(2) The connecting of the cut-off relay BR to the line-finder multiple "*c*" wire.

(3) The "*d*" or front bar of the frame to receive a potential.

Relay LGR connects with the starting distributor, common to 500 lines and relays SSR_1 and SSR_3 actuating, cause

(1) The starting distributor to rotate by energizing the clutch magnet S.

(2) The starting distributor arresting relay SSR_2 to be connected through resistance r_1 in parallel to all line finders which are hunting, it being gauged that ten or so such resistances in parallel will actuate relay SSR_2.

(3) Actuate relays RS_3 of those line finders which happen to be coupled in over the starting distributor contacts.

A relay RS_3 actuating, causes the sequence switch clutch magnet SOS to actuate, carrying its wipers to the second position, when

(1) The "*d*" wiper is connected in through the test relay RS_1 back to the starting distributor.

(2) A circuit actuates the centering relay for rotary motion of the line finder, which causes one of the clutch

magnets, in this case MVS, to rotate the line finder, springs OVS causing a reversal at an extremity.

When the calling frame is found relay RS_1 stops the rotary movement; releases LGR by draining its holding current, which stops the starting distributor (providing this LGR relay was the only one actuated) and also steps the sequence switch SOS to its third position.

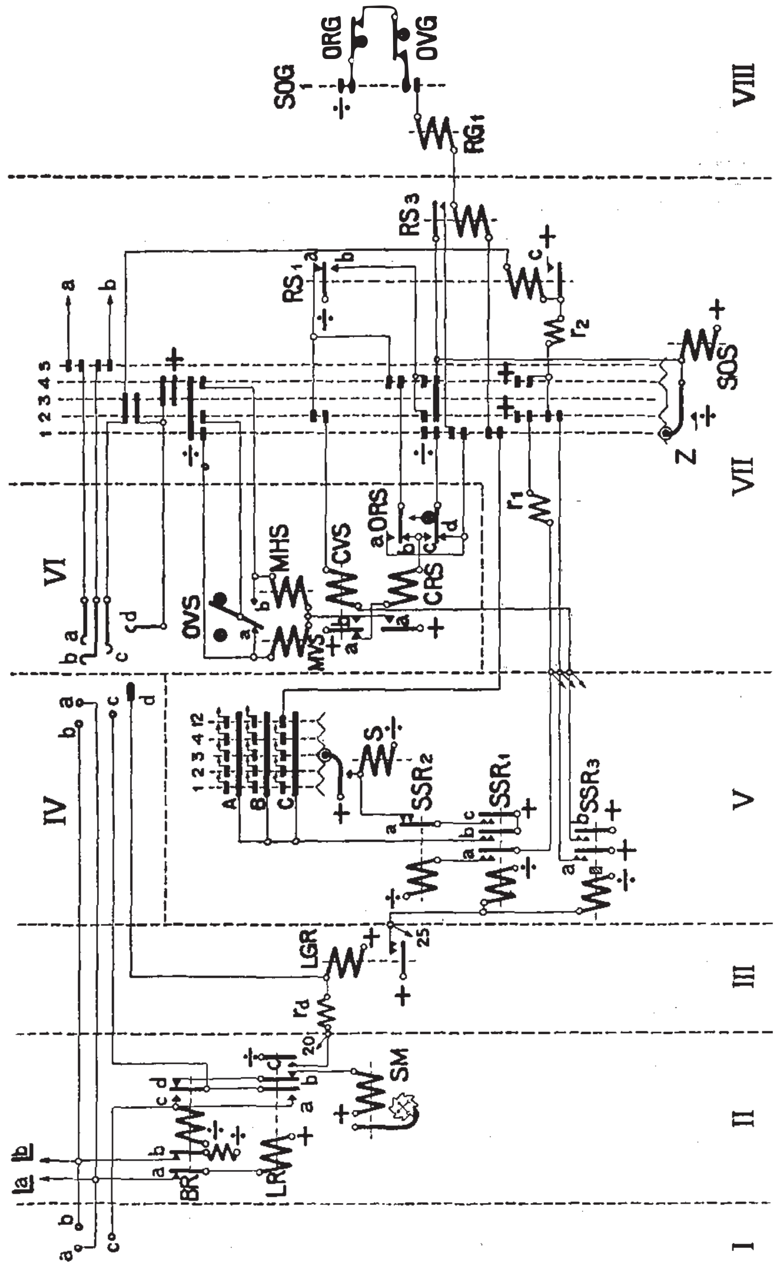


Fig. 19.—Diagram of Line Relay, Starting Distributor and Line Finder.

The sequence switch SOS does not rest on its third position, its centering cam having a blind tooth, which carries it to its fourth position.

In its fourth position it causes

(1) The test relay RS_1 to be transferred from the "*d*" wiper to the "*c*" wiper, the "*d*" wiper being earthed to prevent more than one line finder searching radially.

(2) A circuit to actuate the radial centering magnet CRS, which causes the clutch magnet MHS to move the brush carrier radially along the calling frame.

When the calling line is found, relay RS_1 again actuates, when simultaneously

(1) The cut-off relay of the calling line is actuated in series with it.

(2) This line tests engaged to other calls; the "*c*" wire having now too low a potential to actuate other test relays RS_1 which are marginally adjusted with the resistance r_2 normally in series.

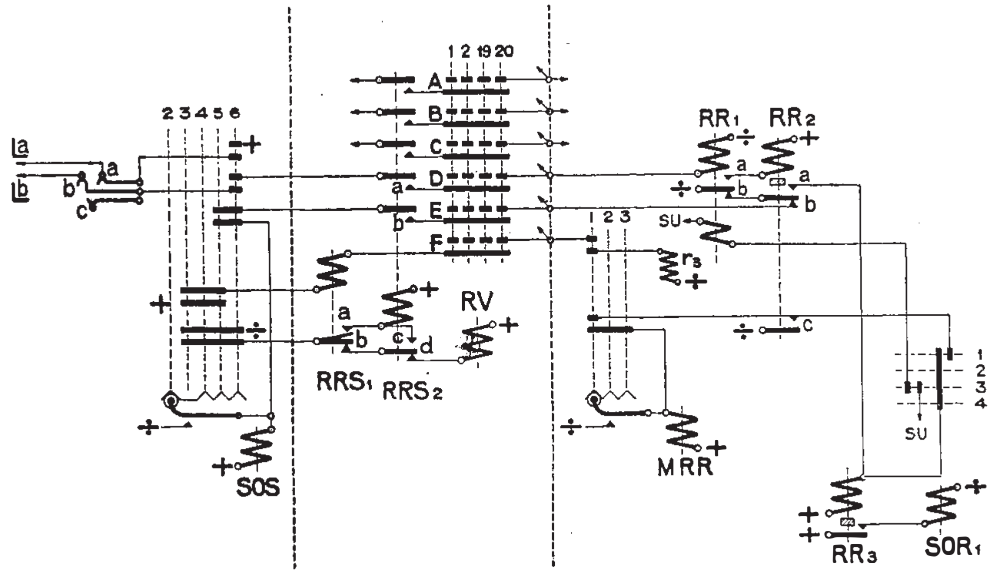


Fig. **20**.—Connecting of Subscriber's Line to a Disengaged Register.

(3) The centering magnet releases, locking the brush carrier on this line and at the same time releasing the magnet clutch MHS.

(4) The sequence switch moves to its fifth position.

The calling line has now been connected to the line finder.

B. The Call is Connected to an Idle Register.

It will be assumed that the connection of the registers is accomplished in accordance with the principle of trunk register finders as shown in Fig. **16**.

Fig. **20** shows in skeleton the method whereby the register is connected to the line finder and consequently the calling subscriber.

When the sequence switch (shown on the left) reached its third position, the clutch magnet RV of the register finder caused its wipers to search.

When an idle register is found, the finder is stopped by RRS_1 which actuates through the normal position of MRR_1 on the register, when RRS_2 couples through the necessary connections.

As previously explained, the sequence switch is moved to its fifth position in the process of connecting the line finder to the calling line, so, when the register is also connected in, a circuit through the normals of relays RR_1 and RR_2 moves the sequence switch to its sixth position.

The immediate effect is that the impulsing relay of the register RR_1 is actuated over the subscriber's loop, breaking this circuit to SOS before it can step to its seventh position.

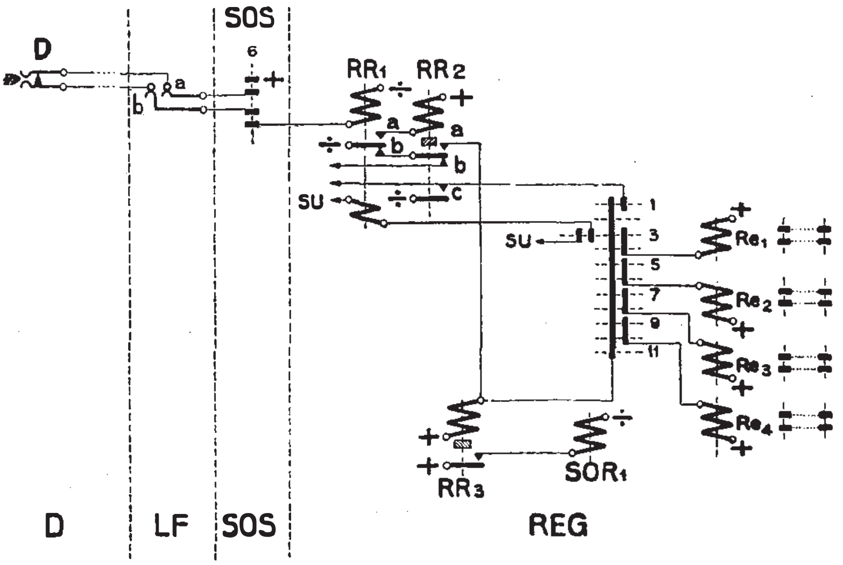


FIG. 21.—SETTING OF REGISTER BY MEANS OF THE CALLING DIAL.

At the same time it will be observed that RRS_1 is released, allowing RRS_2 to retain over its alternative circuit, but RR_1 by actuating the retaining relay RR_2 will cause the side switch MRR to step from the normal position and hold the register busy, by reason of resistance r_3 being disconnected.

A circuit through the normal of switch SOR_1 will actuate relay RR_3, which in turn will actuate SOR_1 and step its wipers to the second position.

Now RR_3 has no circuit so, when it releases, SOR_1 steps to its third position, causing a dial tone SU to be induced over the relay RR_1 to the subscriber's instrument.

(SOR_1 and all impulse responding switches on the registers step two positions for a complete impulse, resting the wipers on even numbers whilst actuated and advancing one step when released).

C. Storing the Number in the Register.

Fig. **21** shows the apparatus involved in storing the call in the register, D being the subscriber's dial, LF the line finder in position, SOS position 6 of its sequence switch and REG the register.

When the tone is heard, the subscriber is at liberty to dial and the result of the first train of impulses must be impressed upon switch Re_1, the second on Re_2, etc., the four such switch wipers assuming positions in conformity with the dialled number.

- RR$_1$ responds to impulses.
- RR$_2$ remains actuated throughout the call.
- RR$_3$ actuates each time RR$_1$ first releases and will retain until a digit train is completed.

When a digit is dialled, the circuit over the back contact of RR$_1$, the front contact of RR$_2$ will actuate RR$_3$, stepping the SOR$_1$ wipers from an odd to an even position without interfering with the parallel circuit through its contact bank to the storing R*e* switch in circuit.

Consequently whilst RR$_3$ retains, the R*e* switch will respond to the train, but the delay between digits, allowing RR$_3$ to release, will couple in the next R*e* switch for a further digit.

D. The Switching Process for the Setting of the Group Selector to its Rotary Position.

Fig. **22** shows

REG	The register apparatus involved in the reception of the back impulses.
RV	The *a, b* and *c* connections through the trunk register finder.
SOS	Position 6 of the line finder sequence switch.
SOG	The group selector sequence switch.
GS	The rotating details of the group selector.

It is necessary that the first two digits be recorded in the register before the group selector be set. Then the SOR$_1$ switch will have reached position 7—8, and consequently the side switch MRR will be stepped to its third position.

Relay GR$_2$ will actuate, moving the group selector sequence switch to the second position, GR$_2$ retaining over its own contacts.

In this position the rotary centering magnet CVG is actuated, causing the clutch magnet MHG to rotate the group selector from its normal position. Each frame position passed will send back a make alternating with a break, to RR$_7$ of the register, which will cause Re_5 switch to impulse, advancing a step for each new location of the group selector until its wipers rest on contacts conforming to the setting of the first two storing switches Re_1 and Re_2.

In this position relay RR_8 is actuated, breaking the circuit to RG_2 which, by releasing, stops the group selector at the required multiple frame and also steps its sequence switch to the third position.

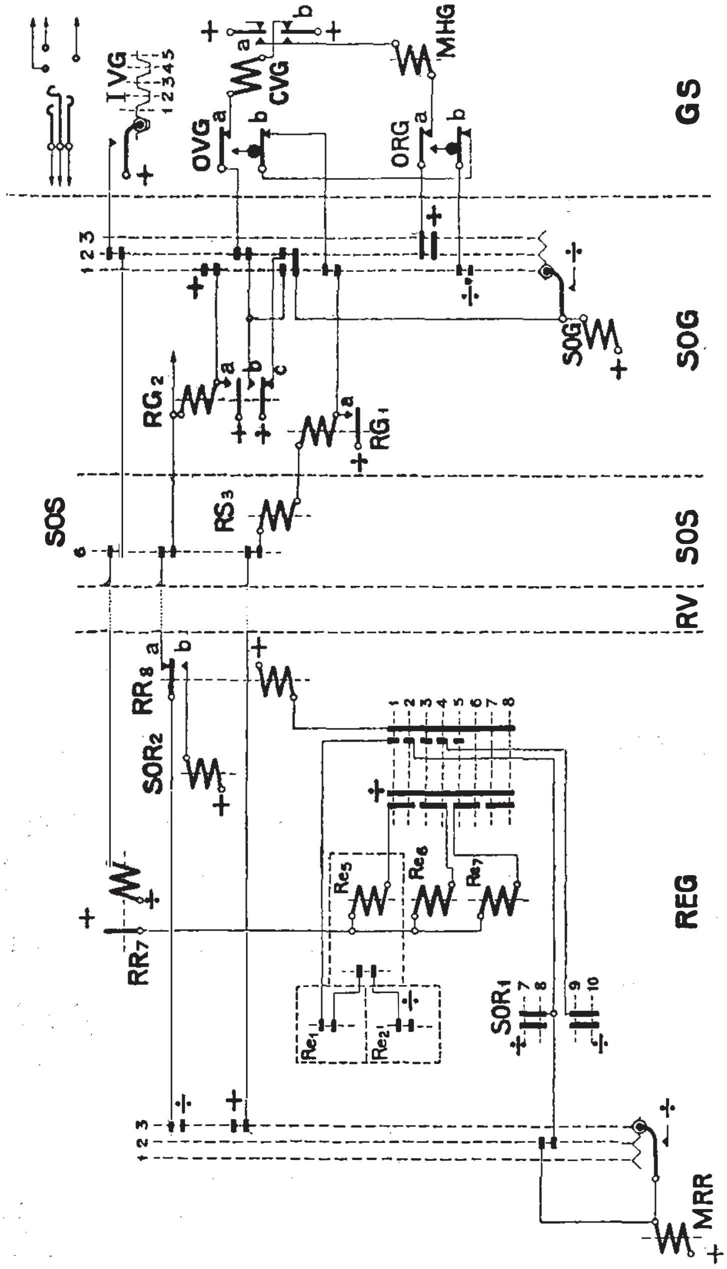


FIG. 22.—SETTING OF GROUP SELECTOR BY MEANS OF THE REGISTER.

Now the magnet SOR_2 of the sequence switch for successively coupling in the back impulse switches Re, will step its wipers to the second position and remain there if the next number dialled has not been received to move SOR_1 from position 7—8.

Providing the third digit is recorded, SOR_2 on its release, steps its wipers to position 3, coupling in switch Re_6.

E. The Group Selector seeks for an Idle Connector.

The group selector has now selected the five hundreds frame in which the wanted number lies, and Fig. **23** shows the process of finding an idle connector in this frame.

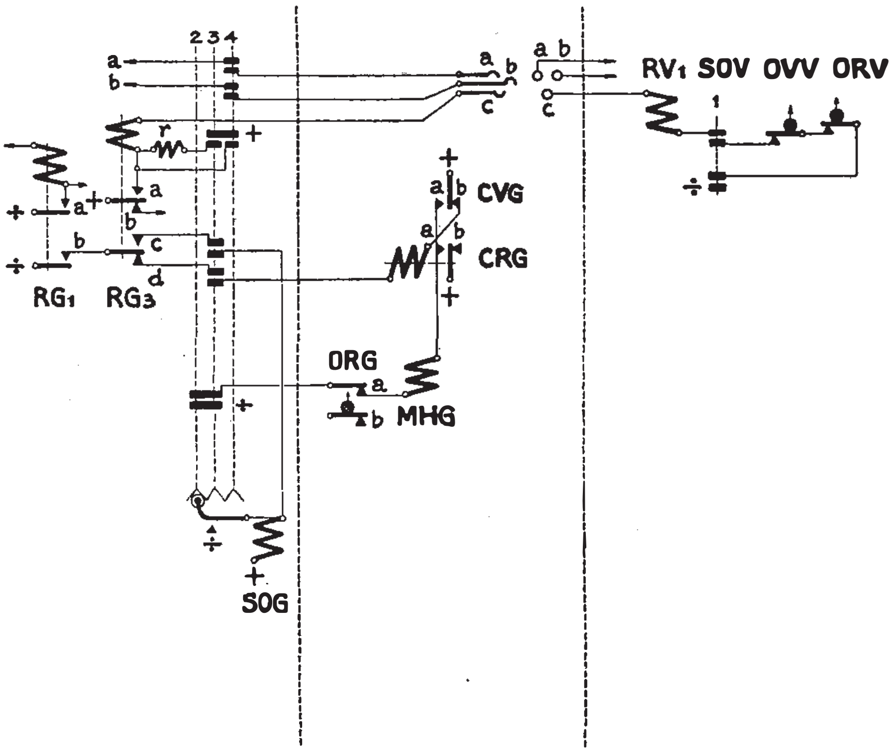


FIG. **23**.—THE GROUP SELECTOR SEEKS AN IDLE CONNECTOR.

Relay RG_1 operated when the group sequence switch was in its first position (Fig. **22**) and has since retained over its own contacts so, SOG now being in position 3 a circuit operates the radial centering magnet CRG which, in turn operates MHG, the clutch magnet for outward radial movement.

This causes the brush carrier to travel down the frame, the " C " wiper progressively contacting with the connector test wires.

A connector to test free, must have its sequence switch SOV in its first position and the rotary springs OVV and radial springs ORV at normal, and when such a connector is found, test relay RG_3 actuates, both stopping the radial movement and connecting the *a* and *b* wires through, by moving SOG to its fourth position.

F. The Setting of the Connector to its Rotary Position.

This process is identical to the rotary setting of the group selector, and when accomplished the SOR_2 switch in the register advances to or awaits the connecting in of Re_7, depending upon whether the last digit has been stored.

G. *The Connector is set Radially.*

This is accomplished in the same manner as the rotary setting.

H. *Restoring the Register.*

With the radial setting of the connector the register has completed its function and can be released for further calls.

After the reception of the last series of back impulses, SOR$_2$ switch steps from the Re_7 switch on contacts 5 and 6 (Fig. **22**) to 7 and 8 (Fig. **24**) causing the line finder sequence switch SOS to step to position 7.

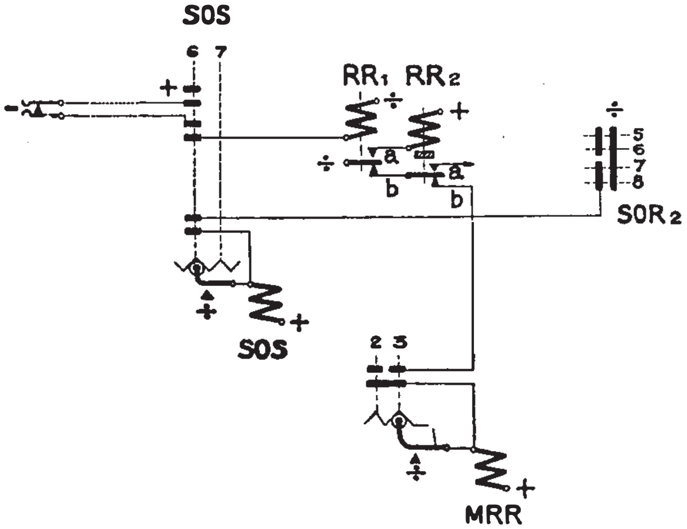


FIG. **24**.—RESTORING THE REGISTER.

Relay RR$_1$ is disconnected from the subscribers' loop and its release, along with that of RR$_2$ will actuate the side switch MRR which, by clutching the driving shaft, will cause a cam shaft to rotate and thus reload all register switches to normal.

I. *The Connector Testing to ascertain if the Called Number is engaged.*

Fig. **25** shows the connector in conjunction with the line and cut-off relay of the called number. After the process of setting the connector, its sequence switch SOV rests in its sixth position, but, whilst passing its fifth position, the test relay RV$_3$ was connected to the cut-off relay BR of the called number. (Relay RV$_1$ is actuated from another source).

Should this line be free RV$_3$ will actuate, carrying SOV to its seventh position, but should it be engaged RR$_3$ will not actuate owing to insufficient current.

In this case SOV will remain in its sixth position, and by projecting a busy tone SU, induced over the feeding coils RV$_5$, advise the caller that the line is engaged.

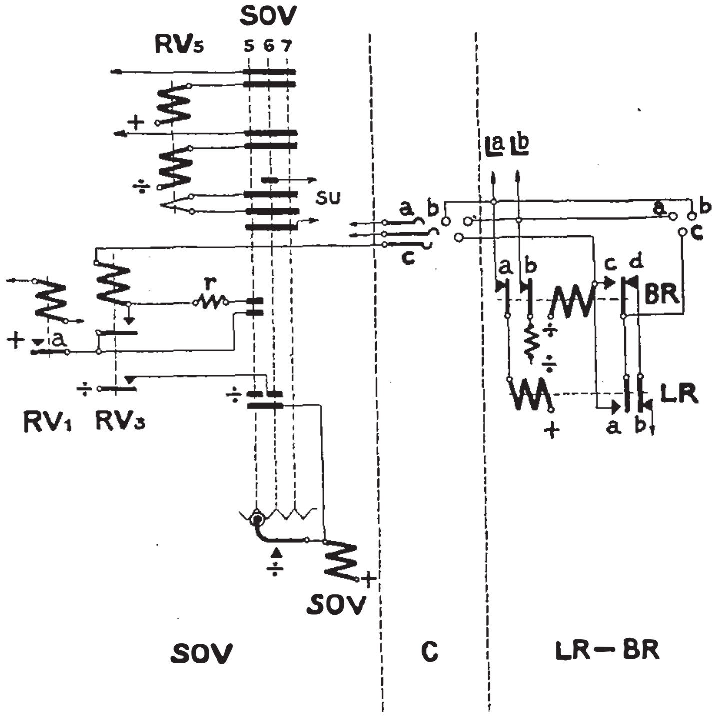


FIG. 25.—THE CONNECTOR IS TESTING THE CALLED NUMBER.

K. A Ringing Signal is sent out to the Called Number.

When the sequence switch SOV (Fig. 26) has attained its seventh position, it will travel to its tenth position by reason of the blind teeth on the centering wheel, in the meantime sending out a preliminary or instantaneous ringing to the called number.

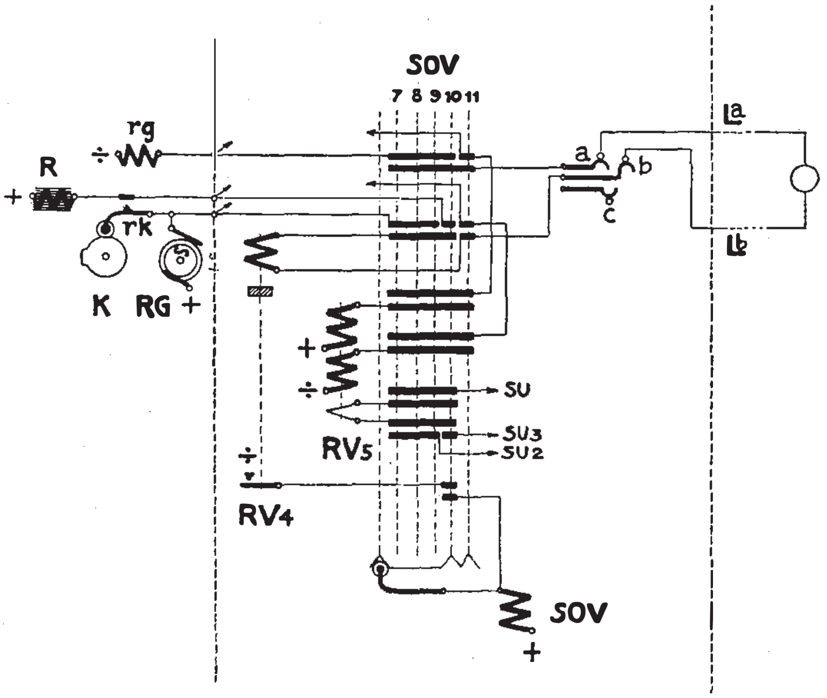


FIG. 26.—A RINGING SIGNAL IS SENT OUT TO THE CALLED NUMBER.

The tenth position causes periodic ringing, which will continue until the ringing trip relay RV_4 is actuated by the number answering, or alternately until the call is abandoned.

First an instantaneous tone SU_2 and then a periodic SU_3 advises the caller that ringing is in progress.

The actuation of the ringing trip relay RV_4 steps SOV to its eleventh position and the manner of stepping the line finder sequence switch SOS (Fig. **27**) left at its seventh position to its ninth position is as follows:—

Relay RR_5, by actuating, short-circuits the test relay RG_3 of the group selector, which on release, causes RS_3 of the line finder also to release, when the SOS magnet moves its wipers from the seventh over the eighth (circuit not shown) to the ninth position.

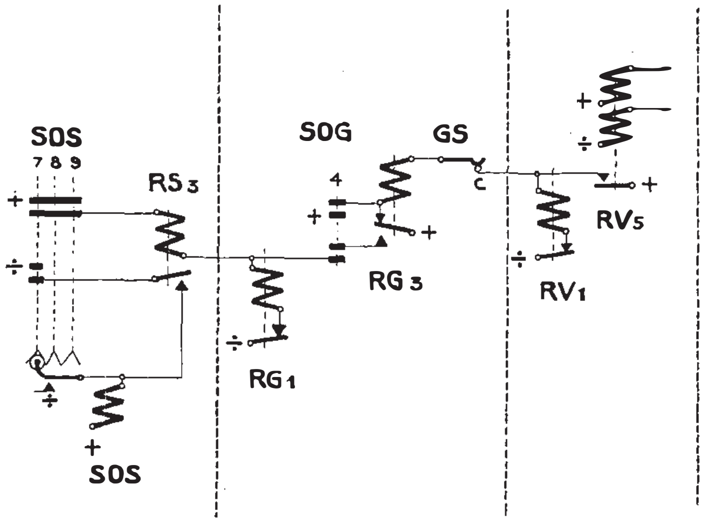


Fig. **27**.—Setting of the Line Finder's Sequence Switch to Speaking Position.

When this is accomplished the speaking circuit in Fig. **28** is established, the various sections showing—

A	The calling subscriber.
BRA	Cut-off relay.
LF	Line finder.
SOS	Its sequence switch and relays.
SOG	Group selector sequence switch and relays.
GS	Group selector.
SOV	Connector sequence switch and relays.
C	Connector.
BRB	Called subscriber's cut-off relay.
B	Called subscriber.

L. Restoring the Selectors and Sequence Switches to normal.

In this case clearing is not effected until both subscribers hang up their receivers, but individual clearing can be substituted at will.

The speaking or feeding relays RS_2 and RV_5 (Fig. **28**) must both release before the apparatus can be restored to normal, the release of RV_1 then starting this operation.

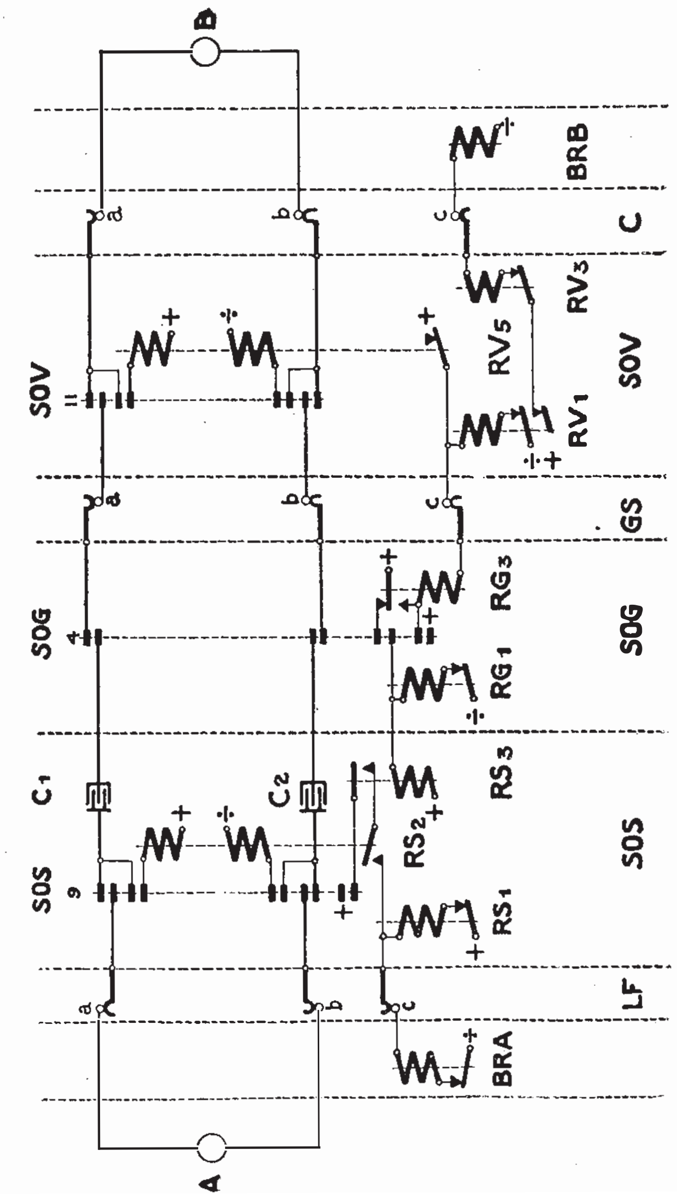


Fig. 28.—Speaking and Holding Circuits.

When RV_5 releases, the short circuit on RG_3 is removed and by its re-actuation, RS_3 of the line finder will also re-actuate over a similar circuit on RG_3. When RS_2 releases, RS_1 will be short-circuited and its release will cause the sequence switch SOS to step from its ninth position over its tenth, eleventh and twelfth to normal again.

In the normal position the line finder brush carrier is withdrawn from the frame.

The series coupling of RS$_3$ to RG$_1$ is discontinued after the tenth position of SOS, so the release of RG$_1$ will then cause the group selector SOG to be reset to normal and in like manner the connector SOV will be restored.

M. The Call is registered on the Subscriber's Meter.

When the sequence switch of the line-finder passes its tenth position the cut-off relay BRA is released and over the eleventh and twelfth positions the circuit in Fig. **29** operates the meter.

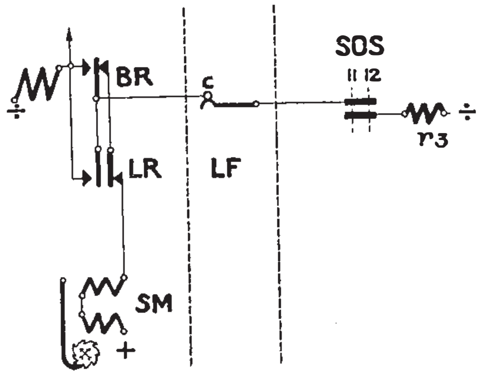


Fig. 29.—Registering a Call on a Subscriber's Meter.

Ineffective calls, where no answer has been received or the call abandoned, the restoring of the line finder is effected from the eighth position of its sequence switch and consequently when this switch later passes its metering positions the brush carrier is already withdrawn from the multiple.

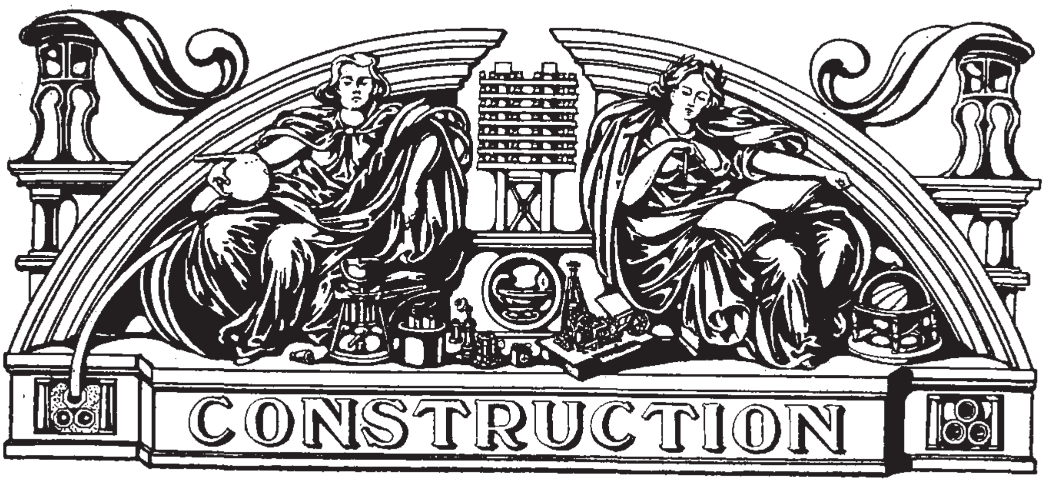
In this manner provision is also made for non-registered calls to toll operators, trouble and information desks, etc.

G.G.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT 31ST MARCH, 1925.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
444,018	617	4,159	57,149	503	London	22,228	47,885	1,515,027	49,412
52,570	1,920	19,412	52,871	1,714	S. East	3,793	19,417	83,049	15,441
55,778	4,372	24,915	42,512	1,684	S. West	13,262	3,964	83,451	27,005
43,479	8,365	30,370	38,732	5,459	Eastern	13,725	21,472	44,524	46,521
75,250	8,553	41,184	50,085	3,339	N. Mid.	17,355	30,529	126,978	78,679
52,623	4,784	25,574	53,540	4,487	S. Mid.	10,607	14,028	103,485	82,781
49,518	5,037	27,900	43,873	1,941	S. Wales	5,194	14,134	77,788	31,416
78,755	8,565	23,526	40,491	4,885	N. Wales	11,813	28,807	140,204	45,155
123,777	2,986	16,837	46,708	3,296	S. Lancs.	12,364	58,481	322,817	38,932
74,318	6,344	29,166	42,014	2,724	N. East	8,070	25,960	153,628	21,002
49,126	3,870	23,785	38,068	2,094	N. West	8,504	27,594	91,685	23,430
38,692	2,526	15,233	23,613	2,117	North	2,755	8,368	60,263	25,199
17,564	4,785	5,894	11,335	234	Ireland N.	139	84	28,478	73
51,299	5,603	20,942	32,443	1,249	Scot. East	1,588	5,995	88,912	11,667
73,958	7,514	22,580	38,770	985	Scot. West	12,386	20,007	181,267	26,814
1,280,725	75,841	331,447	612,204	36,711	Totals.	143,783	326,725	3,101,556	523,527
1,249,748	76,347	327,419	606,427	37,139	Figures on 31st Dec., 1924.	141,380	308,191	3,019,720	461,448



THE ROMFORD TO SOUTHEND-ON-SEA LOADED AERIAL CABLE.

(54 PAIR/40 LB., PAPER CORE, LEAD SHEATHED).*

By A. W. Gardner, A.M.I.E.E.

This aerial cable line is the first of its type, of any considerable length, erected in this Country. It is constructed on a method similar to that adopted in America over long distances, but with some adaptations suitable for this particular work and for coil-loading in manholes. Briefly, it consists of a lead-covered paper-core cable erected on a specially constructed pole route, the cable being suspended on a stranded steel wire by means of steel rings in place of the usual suspenders and the stranded steel wire being strained to such a tension that there is a very small dip. The poles are spaced at 40 yards. The cable, in approximately 400-yard lengths, was drawn through the rings quite easily—in fact, much more so than in the case of a cable drawn into a duct.

A few words upon the position which led up to the decision to erect this type of plant. In 1922 estimates were prepared and authorised for an underground cable along the then proposed new arterial road to Southend, but it was found later that the road would not be completed before the middle of 1924, and also that there would be great risk of dislocation of a duct line, due to possible subsidence of sections of the new road, which in several long sections is made up on embankments formed by the filling in of valleys and hollows. The need for additional trunk lines to

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* Abstract of Paper read before the Institution of Post Office Electrical Engineers, Eastern Centre.

Southend, however, was urgent and it was decided, therefore, to erect an aerial cable line.

In the case of cuttings, the poles are erected at, or near, the foot of the batter or slope: in the case of embankments, the poles are placed at the foot of the embankment. This causes the line to undulate in some parts, as some of the embankments are 30 to 35 feet high.

At Rayleigh a deep cutting through a hill was made, extending for some 900 yards with a high and very gradual batter, very liable to slide and, in fact, numerous slides occurred during the work and have continued since: in this section, therefore, the line was erected over the hill on the top of the cutting and as far from the edge of the slope as possible.

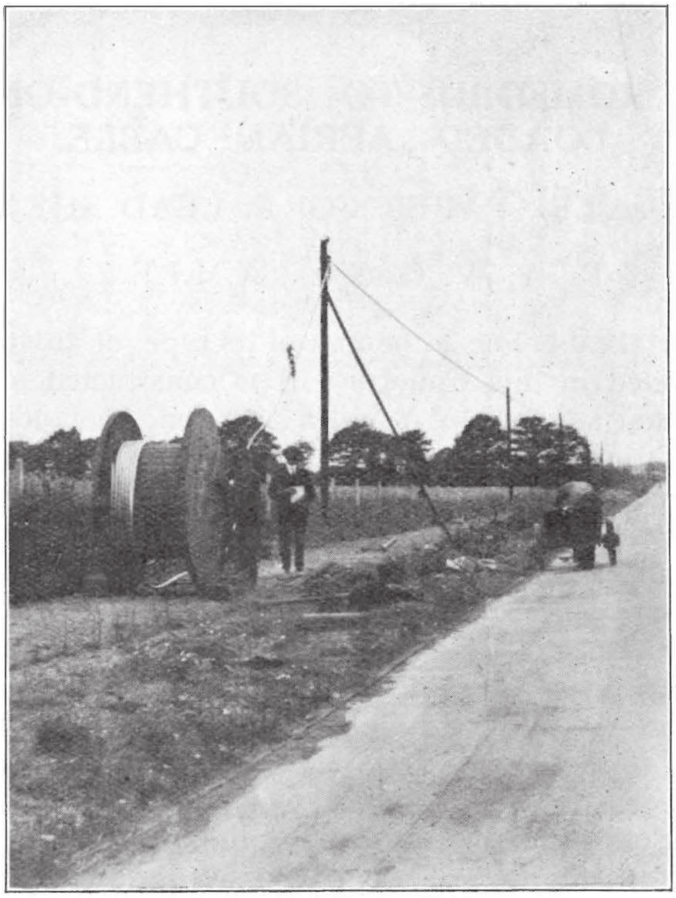

FIG. 1.—CABLING: DRAWING THROUGH CABLE RINGS.

The spans are 40 yards and the poles are 28′ medium and 30′, stout, in the proportion of approximately 3 to 1: if required, the line will carry a second cable similar to that already erected.

Special attention was given to staying, according to the principles in general use for open lines, and the requirements were calculated by the stay slide rule but using the breaking strength of the suspension strand wire (13,000 lbs.) in place of the breaking strength of line wires.

In cases where the "pull on the pole" is more than 50 feet, stays are fitted in prolongation of the line on each side of the angle, in addition to a stay bisecting the angle. At railway crossings the poles are back-stayed against the crossing span and also side-stayed.

Side stays are erected every quarter-mile and line stays every half-mile—that is, at half-mile intervals, the poles are stayed in four directions.

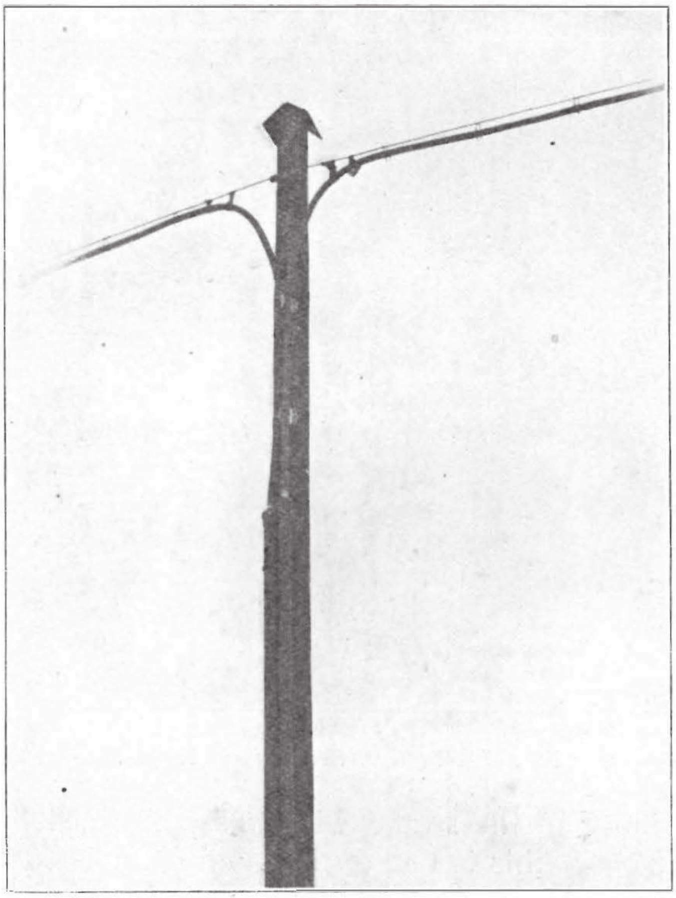

FIG. 2.—METHOD OF LEADING CABLE DOWN POLES.

The side stays are made off 12 inches above the suspender strand, and line stays 4 inches below.

The suspension wire is of 7/10 S.W.G. galvanised steel, the breaking strength being 13,000 lbs. It was supplied on drums in half-mile lengths which were run out and used to the maximum length practicable. It is not an easy wire to handle.

Brackets, known as No. 13, which occupy the same side of the pole route throughout, are used to grip the strand wire.

Each bracket is supported by a bolt passing through the pole at right angles to the cable, the bolts being screwed at each end, so that a second bracket can be added on the other side of the pole when required. An extra washer or nut is inserted between the bracket and the pole in order to give sufficient clearance for the cable.

The strand wire was run out over the ground, lifted over the bracket bolts and then placed in the bracket clamps, which were tightened so as to hold the strand wire but not to injure the galvanizing while the wire was being strained up.

To joint the strand wire, the ends are looped round interlocked thimbles and secured by clamps, three clamps being used on each side.

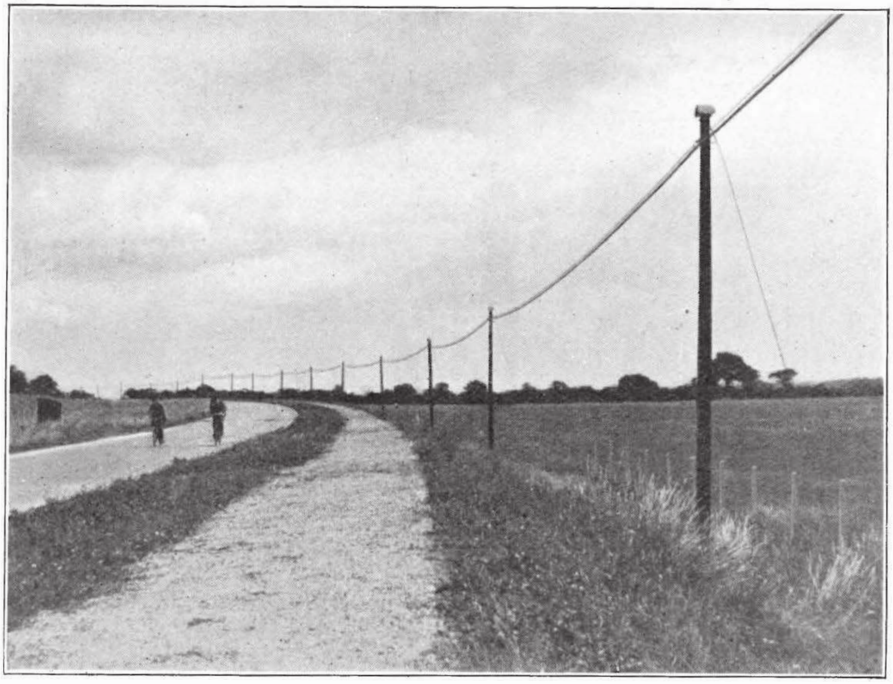

FIG. 3.—TYPICAL SECTION OF ROUTE.

The straining of the strand wire was performed by means of blocks and tackle: this is one of the main features of this type of construction, and the most costly as regards labour. The tension on the unloaded strand was approximately 3,000 lbs. (calculated for the cable, weighing 3.5 lbs. per foot).

The straining of the strand wire was checked by the vibration method, *i.e.*, by counting the vertical oscillations which result from placing a line over the middle of the span and releasing it suddenly. The dip at the centre of a 40-yard span at 40°F. was 19.6 inches and the number of seconds for 40 vibrations was 17.4.

The galvanized steel cable rings are of the "Bonita" type and oval in shape. They are fixed by a man riding in a bosun's chair running on the strand wire, and are spaced 20 inches apart normally and 12 inches at railway crossings.

The chair is hauled along as required by another man by a line attached to the running block and as each ring is fixed a line is threaded through it, to be used later as a draw line. Knots made in the line give the ring fitter the correct spacing.

The cable is 54 pair/40 lb. P.C., M.T., Aerial, external diameter 1.64 inches, and 50 pairs are loaded.

The sheath is an alloy containing 99% lead and 1% antimony, .101 of an inch in thickness and capable of withstanding an internal air pressure of 75 lbs. per sq. inch.

All joints are made at poles. The loading points are at intervals of 1.6 miles and at these points the cable is led into manholes specially designed.

SUMMARY OF WORK.

Poles erected	905
Stays ,, ...	441
Struts ,, ...	40
Number of rings	62,150

Length of cable drawn in—20.65 miles.

INTRODUCTION OF UTILITY SERVICE MOTOR VEHICLE IN THE ENGINEERING DEPARTMENT.

THE vehicle about to be described has been specially designed for use in rural areas, where travelling facilities are poor and much

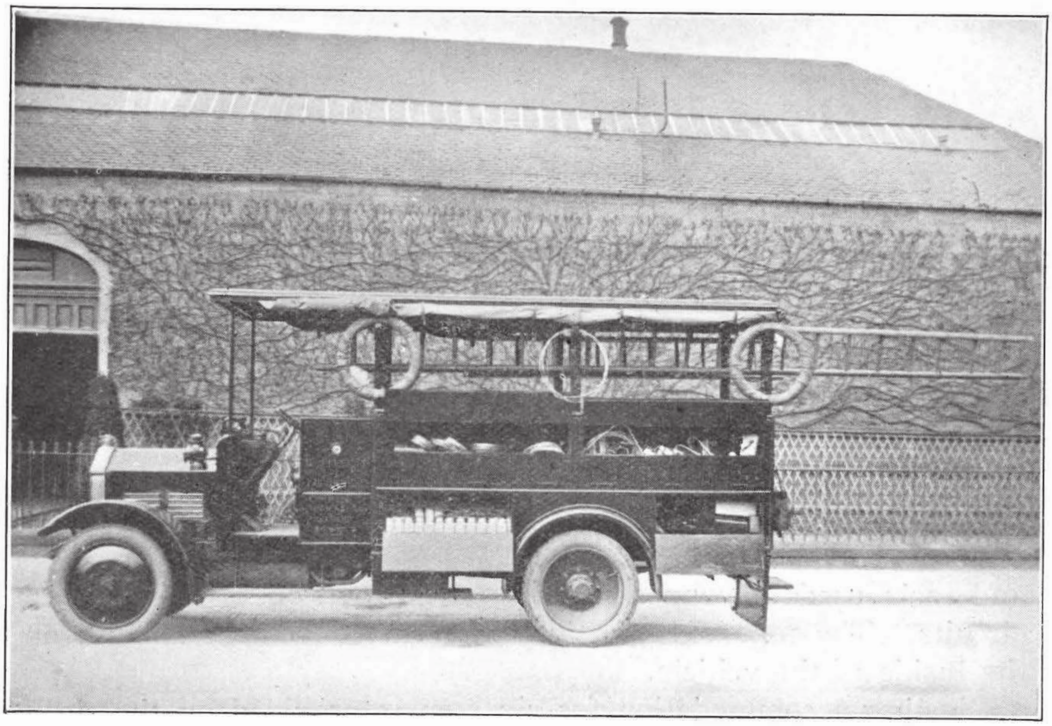

FIG. 1.—SIDE VIEW SHOWING LOCKERS.

time is lost in going to and from the points where new telephone services are required.

The body, attached to a 30-cwt. Albion chassis, subsidy type, is fitted with locker compartments, accessible from the outside, for the various overhead line stores, internal wiring stores, apparatus and tools used in connection with the provision of subscribers' circuits. The tops of these lockers form convenient shelves on the inside of the vehicle.

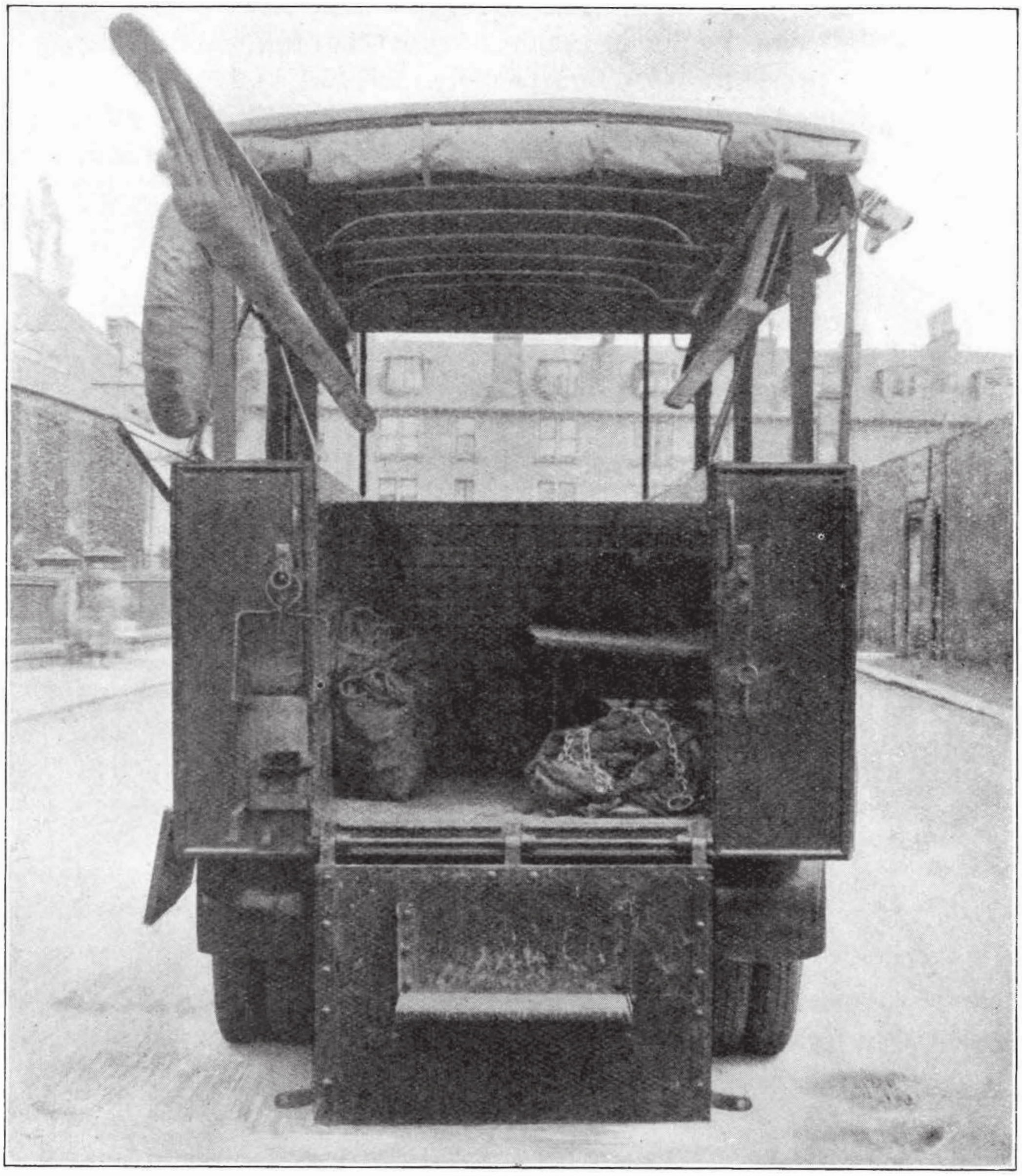

FIG. 2.—REAR VIEW SHOWING INTERIOR EQUIPMENT.

Seating accommodation for six men is provided on the right hand side of the gangway between the lockers. The full length of the vehicle has been made available for passengers by hinging the step to the tail board.

Complete protection from the weather is afforded by curtains on the sides and rear of the body. Those in the illustration have been rolled up to show clearly how the ladders are supported by the hooks on the stanchions. Four ladders can be carried.

The experiment has proved very successful and six more vehicles will shortly be brought into commission.

R.T.R.

QUARTZ CRYSTAL RESONATORS.

By F. E. Nancarrow, A.R.C.Sc., A.M.I.E.E., M.I.R.E.

Early standards of, or means of measuring, the frequency of an oscillating current of radio frequency were based upon accurate knowledge of the characteristics of some standard circuit consisting of an inductance joined across a condenser. Sometimes these circuits were fitted with an indicating device, such as the Neon Tube, in the case of the early Fleming Cymometer, or a rectifying device and telephones, as in the case of the Marconi "Wavemeter."

The modern standard is based upon the frequency of oscillation of a valve-maintained tuning fork, usually of the order of 1000 cycles per second, which frequency can be compared against standard time. This method, which was the subject of an article by the present writer in the October number of this Journal of last year, is probably, and is likely to remain, the most accurate method of measuring radio frequencies.

There are, however, other sub-standards of high frequency oscillations depending neither upon the electrical characteristics of an oscillatory circuit nor upon the low frequency vibration of a tuning fork, but directly upon the frequency of longitudinal vibration of rods of quartz crystal. Their utilisation depends upon two factors; the natural frequency of vibration of a quartz rod and the phenomena known as the piezo-electric effect exhibited by many crystalline substances.

A crystal is said to be piezo-electric when if it be mechanically strained it exhibits an electric polarisation, and conversely when electrically polarised it suffers mechanical strain. An alternating electric stress properly applied will thus set up an alternating condition of mechanical strain.

Rochelle Salt and Quartz are the two crystalline substances which have been mainly studied in this connection, the former by Nicolson[*] and the latter by Cady,[†] who has carried out all the pioneer investigation into the usage of quartz crystals at radio frequencies.

Quite small voltages are sufficient to set a rod of quartz crystal into oscillation when the frequency of the applied voltage coincides with the mechanical frequency of vibration of the rod, and the low mechanical resistance of the quartz makes it eminently suitable as a standard of frequency. The curves given and specified later illustrate the point very remarkably.

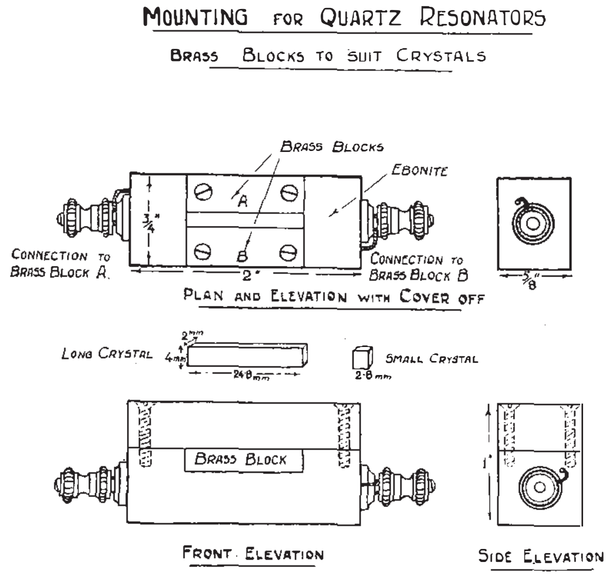
MOUNTING FOR QUARTZ RESONATORS
BRASS BLOCKS TO SUIT CRYSTALS
BRASS BLOCKS
EBONITE
A
B
3/4"
2"
5/8"
CONNECTION TO BRASS BLOCK A.
CONNECTION TO BRASS BLOCK B
PLAN AND ELEVATION WITH COVER OFF
LONG CRYSTAL
2mm
4mm
24·8mm
SMALL CRYSTAL
2·8mm
BRASS BLOCK
1"
FRONT ELEVATION
SIDE ELEVATION

FIG. 1.—MOUNTING FOR RESONATOR.

The constants of quartz, *i.e.*, the density and elasticity, are such that if l be the length of a suitably cut rod in m.m., then the resonant frequency of vibration is approximately given by the relation

$$f = \frac{2.7 \times 10^3}{l} \text{ kilo cycles per second.}$$

In practice, rods can be cut ranging in frequency from about 1000 to 100 kilo cycles per second, *i.e.*, with lengths ranging from 2.7 to 27 m.m. The cross section may be 1 m.m × 2 m.m., so that the rods are always quite small. In order to electrically operate upon the rods they can be mounted loosely between two sheets of a conducting material. Fig. 1 illustrates the type of mounting which has been used in the Radio Laboratory. As is seen, the quartz rods when mounted are eminently portable. Actually the rod is loosely contained within the mounting, the gross clearance in any direction being of the order of 0.5 m.m.

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[*] Proceedings. American I.E.E., 1919.

[†] Proceedings. Institute Radio Engineers, Apl., 1922.

To demonstrate the resonant frequency of a quartz crystal resonator a circuit arranged as in Fig. **2** can be used. Here A is a valve oscillator arranged so that the capacity element by its variation allows of a fine degree variation of the frequency. B is a normal oscillatory circuit consisting of an inductance and capacity, with a thermo-couple and galvanometer inserted in order to read the current. If, now, the circuit B be kept fixed and the frequency of A varied, the readings of the galvanometer will give, providing the coupling between the two circuits is suitably weak, the resonance curve for the circuit B. If, however, the quartz crystal resonator be connected across the condenser of the circuit B, with B set initially to approximately the frequency of the crystal, and the same procedure followed, a frequency will be reached at which the quartz rod is set into oscillation and the consequent absorption of energy will cause the current in the circuit B to fall. How critical is this coincidence of frequency and how marked the result is well shown in Fig. **3**, which illustrates the results obtained with a quartz rod 24.8 m.m. in length. Curve I. was obtained with the circuit B initially set to approximately the resonant frequency of the quartz rod and affords an interesting comparison between the electrical damping of the circuit and the mechanical damping of the rod. The ratio between the mechanical damping of the rod and the electrical damping of the circuit can be roughly taken as the ratio between the width of the crevasse due to the quartz resonator and the width of the resonance curve of the circuit, both widths being taken midway between maximum

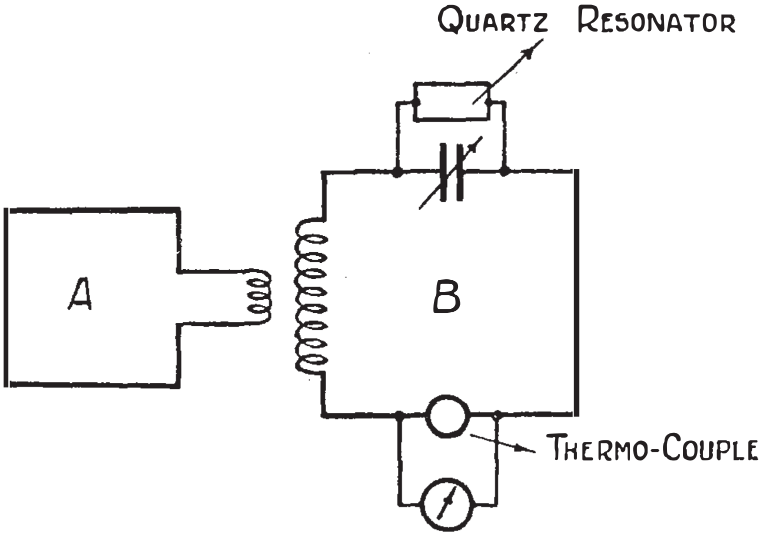


FIG. 2.—CIRCUIT.

and minimum values. Curve II. illustrates the effect obtained when the circuit B is initially mistuned.

Actually the precision with which the oscillator could be set to the resonant frequency of the quartz rod in the above cases was

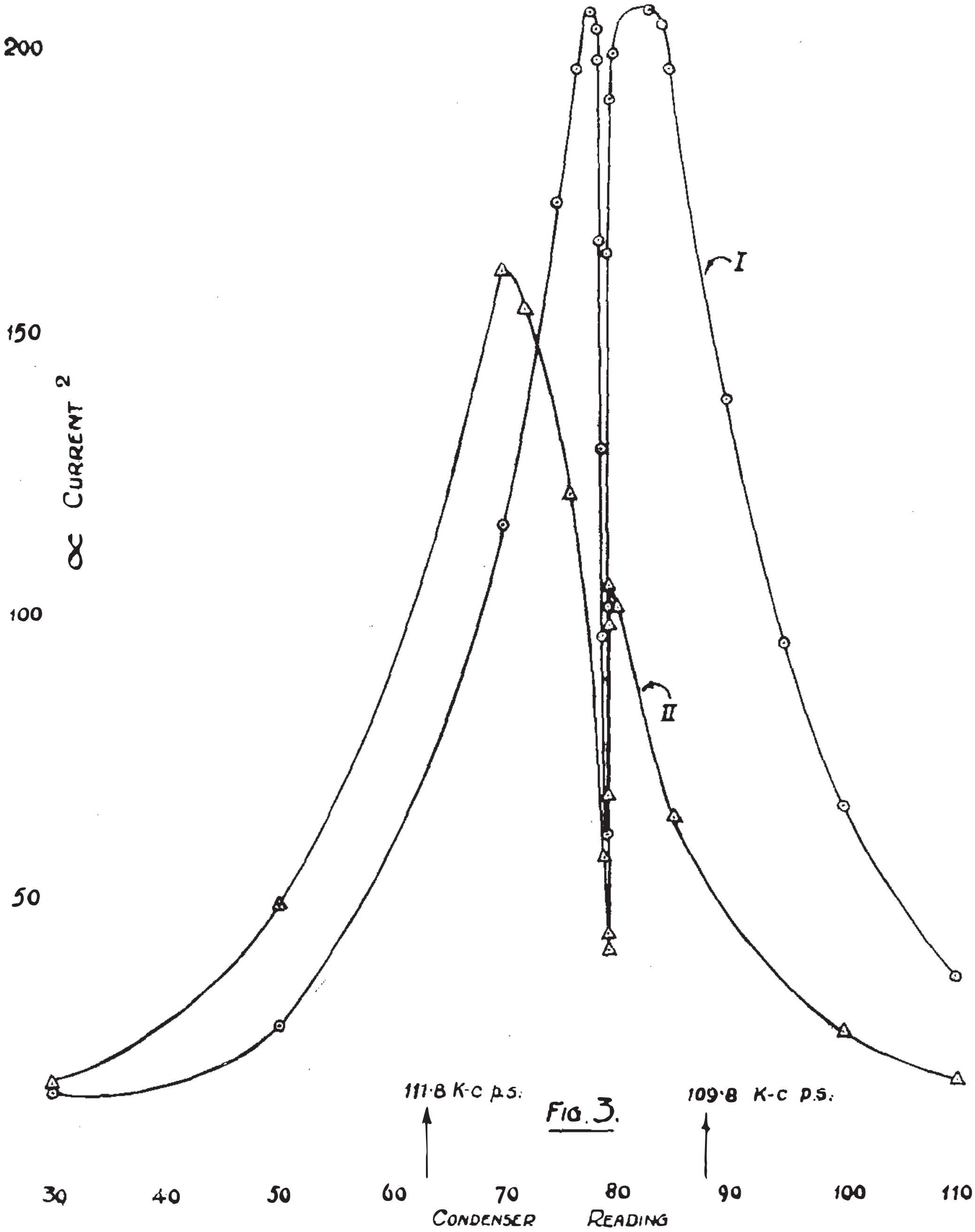


FIG. 3.

of the order of 1 in 50,000, an accuracy much greater than that with which the absolute frequency of the oscillator, and thus the quartz rod, can be measured. The actual measurement of the resonant frequency, once the coincidence of oscillator and quartz rod has been obtained as shown above, is effected by using the

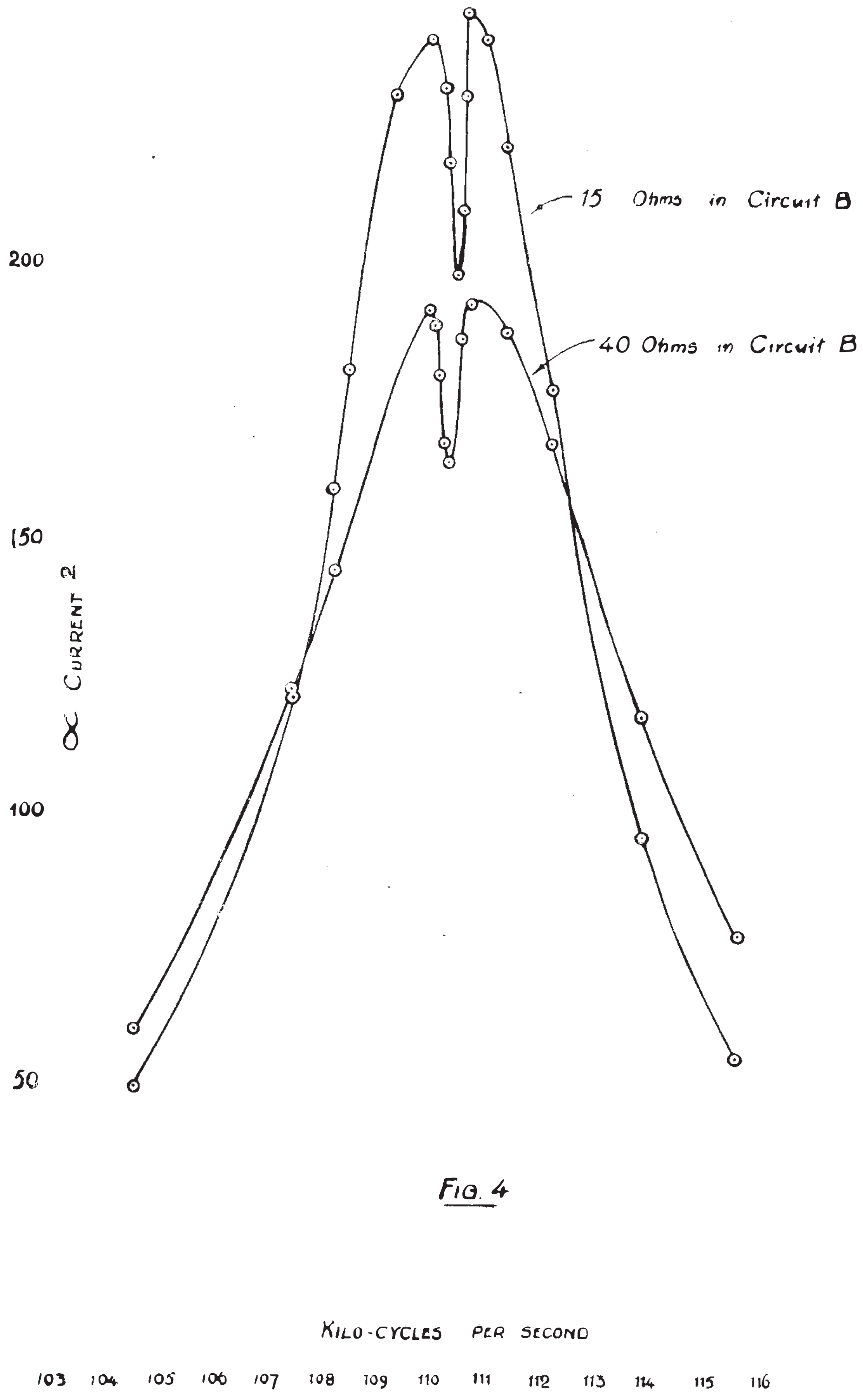

15 Ohms in Circuit B
40 Ohms in Circuit B
200
150
100
50
∝ Current 2
Kilo-cycles per second
103
104
105
106
107
108
109
110
111
112
113
114
115
116

Fig. 4

Multivibrator apparatus previously mentioned, by which means the quartz resonator can be calibrated to an accuracy of 1 part in 10,000.

The nature of the crevasse due to the quartz resonator and thus the operation of setting an oscillator to the exact frequency of the resonator will depend, assuming the oscillator is capable of the necessary fine variation, upon the decrement of the circuit B. In the case illustrated by the curve in Fig. **3**, the circuit had a fairly low decrement, the inductance being of a standard type having a low H.F. resistance. The curves of Fig. **4** give the nature of the crevasses obtained when resistances of fine wire of 15 ohms and 40 ohms respectively had been added to the circuit.

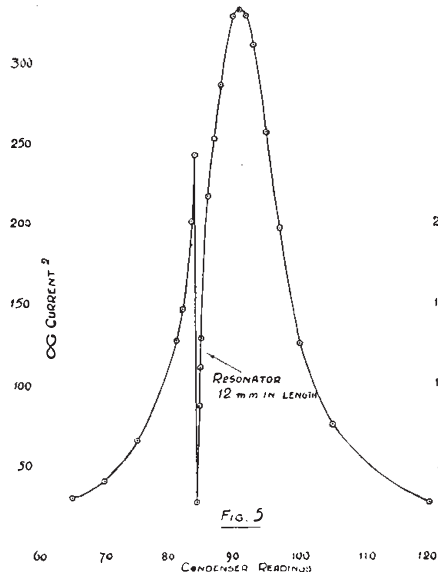


Fig. 5

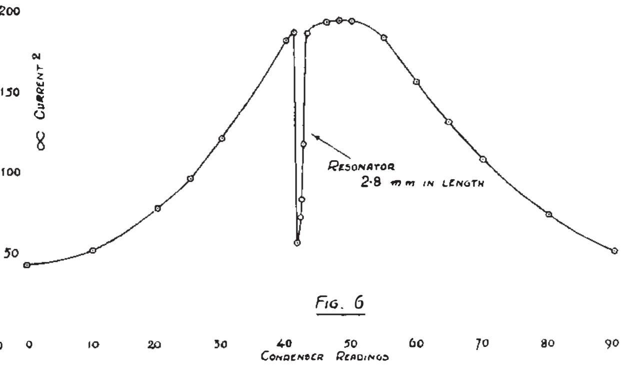


Fig. 6

The delineation of the resonant frequency is not so sharply defined as before, but it is still of a precision equal to that with which the absolute frequency can be measured.

Figs. **5** and **6** illustrate the results obtained with rods of lengths 12 m.m. and 2.8 m.m. respectively, and the Table below gives the resonant frequencies and lengths of a trio of quartz rods recently experimented with.

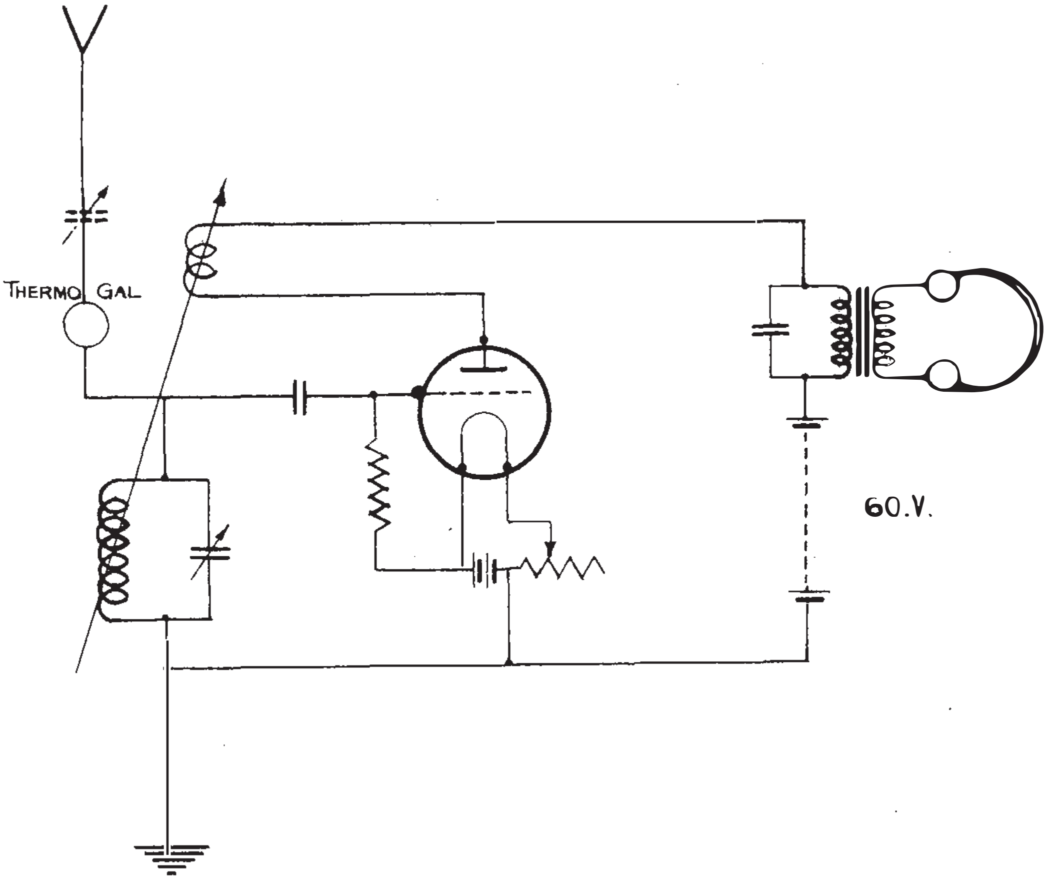
Length of rod.	Resonant Frequency.
2.8 m.m.	957.7_2 k.c.p.s.
12.0 ,,	221.8_8 ,,
24.8 ,,	110.4 ,,

Once calibrated, the quartz resonator becomes a portable sub-standard of frequency, and the reverse of the processes described can be carried out in order to calibrate either an oscillator or a plain oscillatory circuit. Of course a number of such resonators of different frequencies would be required for this purpose.

INTERFERENCE TO BROADCAST RECEPTION BY OSCILLATING RECEIVERS.

TESTS have been made at the Post Office Research Station at Dollis Hill with a single valve having grid circuit connected to aerial and anode reacting thereon.

A single valve receiver with reaction was used; it was direct coupled on to the antenna. Measurements were taken using two different valves in the receiver, a D.E.3 (.06 amp, filament current) and a V.T.3 valve (.85 amp. filament current).



SINGLE VALVE WITH REACTION.

The oscillating current produced in the receiving aerial was measured with a vacuo-thermo junction and mirror galvanometer.

The above is a diagram of the apparatus used.

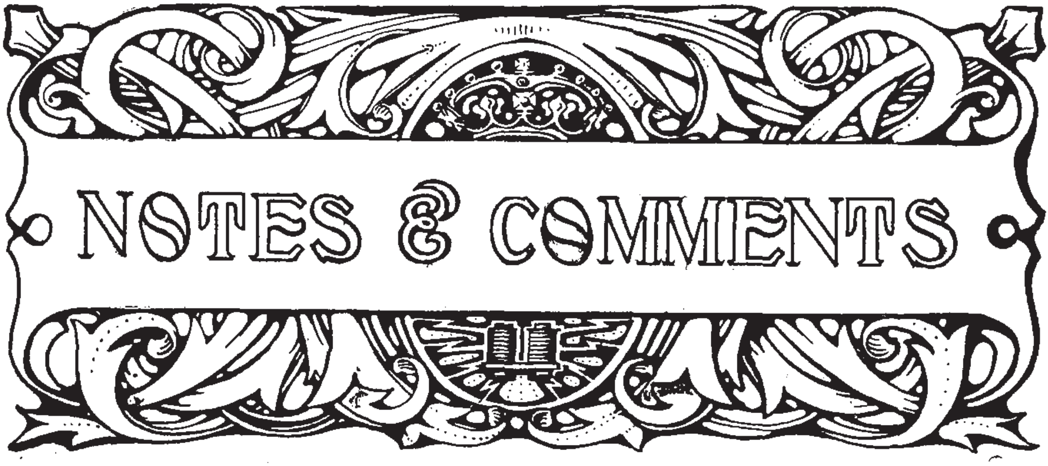
It will be seen that disturbing currents up to a value of 5 milliamperes may easily be obtained.

	Wavelength.	*Valve.*	*Antenna Coil.*	*Reaction Coil.*	*Antenna Current.*
Using Series Condenser.	400 metres	D.E.3.	100 μ H	250 μ H	1.1—3·3 milliamps.
	,, ,,	V.T.3.	,,	,,	1.0—2.0 ,,
	,, ,,	D.E.3.	,,	,,	1.0—4.0 ,,
	,, ,,	,,	,,	500 μ H	2.15—5.0 ,,
	,, ,,	V.T.3.	,,	250 μ H	·9 ,,
	,, ,,	,,	,,	500 μ H	1.0—1.8 ,,
	600 ,,	D.E.3.	250 μ H	500 μ H	·95—3·3 ,,
	,, ,,	,,	,,	1000 μ H	·95—4.1 ,,
	,, ,,	V.T.3.	,,	500 μ H	Would not oscillate.
	,, ,,	,,	,,	1000 μ H	.6—1.8 milliamps.
	1000 ,,	D.E.3.	,,	500 μ H	·7 ,,
	,, ,,	,,	,,	1000 μ H	.7—1.6 ,,
	,, ,,	V.T.3.	,,	500 μ H	Would not oscillate.
	,, ,,	,,	,,	1000 μ H	·5 milliamps.

As the Dollis Hill aerial used is slightly lower in capacity and of higher resistance than the standard P.M.G. aerial, it is probable that slightly higher current values would be obtained on an ordinary broadcasting receiving aerial.

The large disturbing value of such currents will be realised when it is stated that in some transmission experiments carried out by the Post Office, transmitting at Devizes on a 250′ high aerial and a current of 10 MA on a wave-length of 1,800 metres, good CW signals were generally received at Dollis Hill, about 75 miles distant.

On the shorter wave-lengths employed in ordinary broadcast transmissions the amount of radiation would be appreciably greater than on 1,800 metres.



NOTES AND COMMENTS.

THE paper read before the parent Institution by Colonel Purves on " Automatic Telephony " provides the most complete summary of the history and development of the subject yet published in this country, and traces the progress made towards the complete conversion of the British Post Office system. That the entire switching arrangements will ultimately be automatic in operation no one doubts; the authorities are concerned now with the gradual transfer, which must be accomplished without interfering with the services at present afforded, existing facilities must be fully maintained, the new methods must be applied in the most efficient and most economical manner. A fairly complete summary of the Engineer-in-Chief's paper will appear in our pages, we hope, in due course, but in the meantime a limited number of copies has been obtained with the object of supplying them free to regular subscribers who do not secure copies in the usual way from the Institution of Electrical Engineers. Applications for copies should be sent to the Managing Editor, through the local Agents, and stamps to cover the postage should be enclosed with the application.

In our last issue we commenced to publish much fuller lists of Staff Changes than formerly, and it is pleasing to understand that the change is being appreciated. In such a large list there is always a possibility of error, but one mistake in the April number demands, we think, a sincere apology. The name of Mr. R. E. Guthrie, Northern District, appeared among the deaths. We are glad to hear that Mr. Guthrie is not dead; he retired from the service on the 31st December last, and we trust he has still long years of life ahead. We regret the mistake very much and hope there will be no repetition of such an error.

We have been advised by the Commercial Information Department of the Trade Delegation of the U.S.S.R. that the development of the radio industry has made enormous strides in Russia recently and that a radio exhibition is being held in the Polytechnic Museum, Moscow. Nine sections will deal with every phase of the history and development of the industry. The exhibition will continue open till the end of August. Applications from foreign firms who wished to participate were required to be sent in before the 1st of June.

The blowing of one's own trumpet is not always in good taste, but we ourselves are brazen enough to take the opportunity of directing the attention of our readers to a review elsewhere in this issue by Mr. O'dell of a German book on telephone traffic problems. In the bibliography quoted in the book there are 10 references to this journal out of a total of 17 external to the Reich. This is only another proof of the status and influence which the magazine has acquired in the technical literature of our time.

The following letter from Mr. J. G. Hill will be welcomed by all, not only for the valuable contribution to the subject he treats but for the inevitable inference that he is very much alive and as keen as ever to give of his best to the service of his colleagues. He has just completed a trip to the south-west of France, the land of his adoption, and has returned to Dinard in good health and spirits :—

The Managing Editor.

Sir,—I have read Mr. Morice's valuable article on "The Theory of the Shunted Condenser," in your issue of April last, with great interest. The general agreement between the experimental observations and theoretical calculations appears to me to be striking and convincing.

As regards "The 'Law' of the Shunted Condenser," however (Part III, page 10, etc.), I think, without wishing in any way to challenge the conclusions arrived at, that it may be of interest to supplement the useful information the writer has given. It seemed to me, after reading the article, that the following question naturally arises :—Seeing that the supposed "law," if there be a law, has not the meaning which is usually associated with the shunted condenser when the relation $L=CR^2$ obtains, what precisely happens when this relation exists?—After some investigation I arrived at certain conclusions, and as these throw light on an old Post Office practice, they may interest your readers, and I therefore give them.

In the first place I find it convenient to reproduce Mr. Morice's equation (2) and to call it (1), viz.:—

$$i = \frac{V}{R+R_1}\left\{ 1 + e^{-\alpha t}\left[\frac{(R+R_1) - L(\alpha+\beta)}{2L\beta} e^{+\beta t} - \frac{(R+R_1) - L(\alpha-\beta)}{2L\beta} e^{-\beta t} \right]\right\} \dots\dots (1)$$

It will suffice for my purpose to consider the case in which β is imaginary, in which case this symbol may be prefixed by the root of -1 or $\sqrt{-1} = j$. β then becomes $j\beta$ and (1) may be written

$$i = \frac{V}{R+R_1}\left[1 - e^{-\alpha t}\left(\cos \beta t + \left\{ \frac{\alpha}{\beta} - \frac{R+R_1}{L\beta} \right\} \sin \beta t\right) \right] \quad (2)$$

GENERAL.

The angle βt indicates that in t seconds this angle has revolved through βt radians, and when $\beta t = 2\pi$, the angle has revolved through one complete period. In that case $\beta = \frac{2\pi}{t}$. Also by a well known relation $\frac{1}{t} = f$ and therefore $\beta = 2\pi f$. Thus, according to the magnitude of β the transient signal has a periodicity $\beta = 2\pi f$.

Now the attenuation or damping constant α, and the angle β are of such dimensions for telegraph signals such as we are considering, that the transient part of the signal is often practically extinguished by the time the angle βt has revolved through π radians (half a period), and always in less than one period.

In such a case it will be seen, on examination, that the slow periodicity of the transient part of the telegraph signal may be utilised to secure the rapid rise, and even the temporary reinforcement of that signal, by variations of the Sine and Cosine of the angle βt, which may be positive or negative.

EXAMINATION OF EQUATION (2).

In order to properly appreciate the results obtained when $L = CR^2$ it is desirable to first make a brief analysis of equation (2). Three cases may with advantage be considered.

Let the variable part of (2) be written separately and called i_1 thus

$$i_1 = e^{-at} \left[\cos \beta t + \left(\frac{\alpha}{\beta} - \frac{R + R_1}{L\beta} \right) \sin \beta t \right] \ldots\ldots\ldots\ldots\ldots (2a)$$

Case (1). $\beta = 0$. In this case $\cos 0 = 1$. $\sin 0 = 0$ and $\therefore$ (2*a*) reduces to

$$i_2 = e^{-\alpha t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2b)$$

In this case the extinction of the transient signal i_2 depends on the magnitude of the attenuation constant α. This case corresponds to Mr. Morice's example in Table II of the article in question, in which the capacity is 1.483 mf.

Case (2). In (2*a*) let $\frac{\alpha}{\beta} = \frac{R + R_1}{L\beta}$, then (2*a*) reduces to

$$i_3 = e^{-\alpha t} \cos \beta t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2c)$$

Also $L = (RR_1 + 2R^2)C$ ....(2*d*)

In this case the variations of $\cos \beta$ between $\beta t = 0$ and $\beta t = \pi$ result in an increased rate of rise of the telegraph signal as compared with (2*a*). If we take the same constants as those used in the article, viz., $R_1 = 300$ ohms, $R = 700$ ohms, $L = 3.5$ henrys, it is found that the capacity required to satisfy (2*d*) is 2.94 mf. and it will be further found that the example in Table II, where the capacity is 3 mf., may be approximated to by formula (2*c*).

Case (3). In (2*a*) let $\left(\frac{\alpha}{\beta} - \frac{R + R_1}{L\beta} \right) = -A$, *i.e.*, let the quantity in the brackets be negative and call it $-A$, assuming that such a coefficient is practicable. Then (2) becomes

$$i_4 = e^{-at} (\cos \beta t - A \sin \beta t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2e)$$

With this form of equation—other things being equal—the rate of rise of the telegraph signal becomes more and more rapid as A increases in value. In Mr. Morice's table (2) the two examples having a capacity exceeding 3 mf. are examples which may be calculated by this equation. In the case of the example where 10 mf. capacity is utilised the coefficient $-A = -1$ approximately. With the constants used this is a coefficient very favourable for rapid rise and temporary reinforcement of the telegraph signal.

There is in reality a fourth case where A is positive; but it presents no advantage for our purpose, and is neglected.

Summary of the Analysis of (2*a*).

It is possible to choose and arrange the constants of the shunted condenser and relay under (3) heads. In order to obtain a rapid rise and temporary reinforcement of the signals, arrangement No. (3) (equation (2*e*)) is the most advantageous.

WHEN $L=CR^2$.

When $L=CR^2$ the resulting equation is of the form (2e), Case (3), and is favourable to rapid rise of the telegraph signals.

Let $L=CR^2$ and substitute this value of L in (2*a*). In that case $\left(\frac{\alpha}{\beta} - \frac{R+R_1}{L\beta}\right)$ becomes $\frac{\alpha}{\beta} - \frac{R+R_1}{\beta CR^2} = \frac{\alpha}{\beta} - \frac{1}{\beta}\left(\frac{1}{CR} + \frac{R_1}{CR^2}\right) = \frac{\alpha}{\beta} - \frac{1}{\beta}\left(\frac{1}{CR} + \frac{R_1}{L}\right) = \frac{\alpha}{\beta} - \frac{1}{\beta}\, 2 \left\{ \frac{1}{2}\left(\frac{1}{CR} + \frac{R_1}{L}\right)\right. = \frac{\alpha}{\beta} - \frac{2\alpha}{\beta} = -\frac{\alpha}{\beta}$ Equation (2*a*) then becomes

$$i_5 = e^{-\alpha t}\left(\cos \beta t - \frac{\alpha}{\beta} \sin \beta t\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2f)$$

For values of R between 300 ohms and 1000 ohms the value of $-\frac{\alpha}{\beta}$ varies between -0.7 and -1. These figures are selected as giving a sufficiently wide range of variation of the resistance shunting the condenser in connection with the Post Office Standard " B " relay. If, however, the range of R is extended beyond 1000 ohms the further change in $-\frac{\alpha}{\beta}$ is only small. As an example of (2*f*), take again the case where $L=3.5$ henrys, $R_1=300$ ohms and $R=700$ ohms. Then for $L=CR^2$ we have $C=7.14$ mf. In that case (2*f*) becomes

$$i_5 = e^{-113t}(\cos 191t - 0.745 \sin 191t).$$

It is evident that when $\cos 191t = 0.745 \sin 191t$ (2*f*) becomes $e^{-143t} \times 0 = 0$, and (2) becomes $i = \frac{V}{R+R_1}$ which is the value of the current for the permanent signal, and this value will be attained in a little less than 0.005 second. The current will afterwards be reinforced and temporarily rise above its normal value in an analagous manner to some of the curves in Fig. V of the article in question.

A remarkable case occurs when $L=CR_1^2$ and $R=R_1$ for then $\alpha = \frac{1}{CR}$ $\beta = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{C^2R^2}}$ (Since $L=CR^2$) $= \frac{1}{CR}$, so that $\alpha=\beta$ and (2*f*) becomes

$$i_5 = e^{-\alpha t}(\cos \beta t - \sin \beta t).$$

Now since $\beta = \frac{1}{\sqrt{CL}}$, those familiar with this type of equation will recognise that $\beta = \frac{1}{\sqrt{CL}}$ indicates that the circuit oscillates at the resonance frequency which would occur if there were neither resistance nor leakance in it, although in fact there are both. A relatively low impedance is also indicated. Although the form of the equation indicates a rapid rise of current the equation is not suitable for the required purpose, because the limitation $R=R_1$ results in a relatively small value of α and β, which is not the best arrangement for the shunted condenser in connection with the Standard Relay B. The capacity required would also be relatively high. It may be worth noting, however, that the attenuation constant obtained in this case is exactly the same as if neither resistance R nor capacity C had been added to the relay circuit. The great advantage in this case (when $L=CR_1^2$) is that an additional powerful effect is obtained from the factor $\cos\beta t-\sin\beta t$, in addition to the effect of formula (2*b*).

Further, in the general case when $L=CR^2$ the attenuation constant α varies directly as $R+R_1$, for

$$\alpha=\tfrac{1}{2}\left(\frac{R_1}{L}+\frac{1}{CR}\right)=\tfrac{1}{2}\left(\frac{R_1}{L}+\frac{R}{CR^2}\right)=\tfrac{1}{2}\left(\frac{R+R_1}{L}\right)$$

I have assumed throughout, as indicated by Mr. Morice's experiments, that notwithstanding variations of impedance calculations of the type here made give a useful indication of the results to be expected.

Conclusion.

When the relation $L=CR^2$ exists in connection with the shunted condenser arrangement here considered, the conditions are generally favourable for a rapid rise and a temporary reinforcement of the permanent telegraph signal. It does not, however, necessarily follow that this arrangement is the best. Each case should be considered on its merits.

As a rule for application in the absence of more detailed information the relation $L=CR^2$ may be made very useful if the capacity used is not great (the highest capacity used in the experiments would be well within the permissible limit).

Finally, I may say that this study is not intended to be exhaustive; for example, it is possible to give rules for the best type of signal from permissible constants, but in order to do this it would be necessary for me to have reference to data referring to the transient voltage in the shunted condenser, which I published some time ago. As I am, however, at the moment, far from my sources of information, this must be left.

Yours faithfully,

J. G. HILL.

MEGA- AND MICRO-.

The mega-volt and the micro-volt may be regarded as appropriate symbols for the two important Conferences which are about to take place in Paris, as we go to Press. Big-power is represented by the "International Conference on the extension of High Tension Power Systems," which meets on Tuesday, the 15th June, and little-power by the next Session of the famous "Comité Consultatif Internationale des Communication Telephonique a Grande Distance," which follows a week later. The two Conferences cannot be regarded as entirely independent, so important has the question of interference with telephone service by big-power now become. The danger to life and hearing is not confined to direct contact between the big and little-power conductors, for very appreciable voltages have been picked up inductively by telephone wires. The British Post Office representative at the big-power Conference is S. C. Bartholomew, whose work on the subjects of *interference* and *protection* are so well known. Mr. Bartholomew attends in the dual capacity of representing the Post Office and the Institution of Electrical Engineers in Paris and it will no doubt be recollected that Mr. Bartholomew's recent paper before the I.E.E. on "Interference" earned the Institution's Webber Award for 1924-5. Both Conferences are discussing *directives* (guiding principles on the subject drawn up by the Comité Consultatif and *big-power* will be represented at *little-power's* Conference.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Kirkcaldy	Auto	680
Leeds (Modifications) ...	,,	—
Risca	,,	54
Bristol Extension ...	Manual	80
Cheetham Hill Extension..	,,	440
Clissold Extension ...	,,	1500
Edgbaston Extension ...	,,	1060
Enfield New	,,	1800
Higher Broughton New...	,,	1320
London Toll Extension ...	,,	—
Mill Hill New	,,	600
Northampton Extension ...	,,	1040
Tilbury New	,,	666
Weston-super-Mare New...	,,	870
Booth & Co.	P.A.B.X.	40
Cardiff Union	,,	50
Coopers Stores, Glasgow...	,,	80
Dunlops Extension ...	,,	100
Lovell & Christmas ...	,,	40
Scottish Auto Assn. ...	,,	50
Willis Faber Extension ...	,,	10

Orders have been placed for the following New Exchanges :—

Exchange.	Type.	No. of Lines.
Bedford	Auto	1450
Coventry	,,	3100
Morningside, Edinburgh	,,	2335
Murrayfield, Edinburgh	,,	1605
Newington, ,,	,,	1980
Camberley	Manual	720
Gravesend	,,	1240
Slough	,,	540
Balfour, Ltd.	P.A.B.X.	30
Birmingham Maternity Hospital	,,	20
Co-op. Wholesale Society	,,	160
Crosse & Blackwell	,,	180
Langs Bread	,,	30
London Express Newspaper	,,	120
Shell-Mex, Ipswich	,,	25
Wallpaper Manufacturers	,,	30

Orders have been placed for extensions to existing equipments as follows :—

Exchange.	Type.	No. of Lines.
Stanningley	Auto	260
Stockport	,,	880
Swansea	,,	440
Barnsley	Manual	300
Chester	,,	460
Clissold	,,	2700
Ravensbourne	,,	1200
Rossendale	,,	320
Rusholme	,,	500

TELEPHONE REPEATER STATIONS.

The installations of the following Repeater Stations have been completed by the Contractors :—

Fenny Stratford (Permanent), Derby (Permanent) and Aldeburgh.

We hope to be able to give a complete detailed description of a typical telephone repeater station in our next issue.

LONDON DISTRICT NOTES.

MILEAGE STATISTICS.

DURING the three months ended 31st March, 1925, the following changes have occurred :—

Telegraphs.—Nett decrease in open wire of 135 miles and a nett increase in underground of 131 miles.

Telephone (*Exchange*).—Nett increases in open wire and underground of 277 miles and 17,409 miles respectively, and a nett decrease in aerial cable of 882 miles.

Telephone (Trunks).—Nett increases of 6 miles and 1,666 miles in open wire and underground respectively.

Pole Line.—Nett increase of 94 miles, bringing the total to date to 5,078 miles.

Pipe Line.—Nett increase of 147 miles, making the total to date 5,904 miles.

The total single wire mileages at the end of the period under review were :—

Telegraphs	23,866
Telephone (Exchange)	1,573,001
Telephone (Trunks)	53,325
Spares	49,915

EXTERNAL CONSTRUCTION.

Exchange Lines and Extensions provided and recovered during the quarter ended 31st March, 1925 :—

	Exchange Lines.	Internal Extensions.	External Extensions.
Provided ...	9,728	7,261	1,006
Recovered ...	2,841	2,979	582
	6,887	4,282	424

INTERNAL CONSTRUCTION.

New Exchanges.—New Manual Exchanges have been opened at Malden (C.B.10. 700 lines), Palmers Green (C.B.1. 2200 lines), Mill Hill (C.B.1. 600 lines) and Tilbury (C.B.10. 700 lines). The construction of new Manual Exchanges at Enfield, Albert Docks and Sloane (temporary) is nearing completion.

Exchange Extensions.—Extensions of Exchange equipment are in progress at over 50 of the Exchanges in the London Engineering District.

P.A.B.X.'s.—The Private Automatic Branch Exchanges which are being installed under contract by Messrs. Siemens Brothers for the Port of London Authority at the various Docks are nearing completion, and it is anticipated that the installation will be brought into commission during July. The P.A.B.X. for the Prudential Assurance Company has been completed.

MR. JOSEPH HENRY STANHOPE.

MR. J. H. STANHOPE, Assistant Superintending Engineer, London Engineering District, terminated his service with the

Department on 30th April, 1925, after completing 44½ years' service in the Post Office, of which 29 years were spent in the Engineering Department.

Mr. Stanhope entered the Service at Leeds in 1880. He grew to be a man of exceptional physical strength and great energy. It was his habit to walk the nine miles to and from his place of duty at whatever hour his duty began and terminated. He was always jovial, good natured, and under his somewhat bluff exterior a most sympathetic and kindly man. Many officers in the Engineering Department will miss his cheerful personality and his very ready and valuable advice.

At the transfer of the Telephone Trunks to the Department, Mr. Stanhope was one of the officers selected for the work of fitting up Exchanges and he dealt with the equipment at many places in the North of England. In 1896 he was appointed Sub-Engineer in the Leeds Section. In 1898, he was promoted to 2nd Class Engineer at Headquarters, and in 1901, he became a First Class Engineer in charge of the Bradford Section. He was transferred to London in 1903 as First Class Engineer in charge of the Central Exchange and the Trunk Exchange at the G.P.O. South, where he remained until 1909, when he was promoted to be Assistant Superintending Engineer in the South Metropolitan District. In 1906 Mr. Stanhope was commended by the Postmaster-General in connection with the transfer of the City and Central Exchanges and again in 1908 he received the commendation of the Secretary and the Engineer-in-Chief for the successful manner in which the work in connection with the Knightrider Street extension of the Central Exchange was carried through. On the amalgamation of the Metropolitan Districts at the end of September, 1912, he became an Assistant Superintending Engineer in the London Engineering District. When Mr. Stanhope came to the District the number of faults per station per annum was 3.52. In the fault returns for April, 1925, the number was .93. This marked improvement is a glowing testimony to the energy displayed by him in his duties as Assistant Superintending Engineer in charge of Internal and External Maintenance.

As a token of the respect in which he is held, Mr. Stanhope was presented on the day of his retirement with a gold watch, suitably inscribed, and a pair of Goerz binoculars, together with a gold brooch for his mother, with whom he resides. The presentation was made at Denman Street by Mr. R. McIlroy, Superintending Engineer, in a very human and kindly manner, before a large and representative gathering. Many expressions of good feeling were forthcoming on all hands, among the speakers being Mr. Alex. Moir (late Superintending Engineer). Several humorous references were made to Mr. Stanhope's characteristic mode of expression, and a cheerful note, which was specially welcome, accompanied the proceedings throughout.

Mr. Stanhope's many friends will learn with interest that he has taken up the position of Engineer of the Jersey States Telephones. His success in this position will be assured if he exerts anything approaching the energy he has displayed during his service with the Post Office.

All his colleagues wish him good health and happiness in his new sphere.

R.A.W.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ANNUAL MEETING.

The Nineteenth Annual Meeting of the Institution was held at the Institution of Electrical Engineers, London, on the 12th May, the President, Colonel T. F. Purves, in the Chair.

The Annual Report of the Council was presented by the Assistant Secretary and was approved by the meeting on the motion of Mr. S. C. Bartholomew, seconded by Capt. J. G. Hines.

The financial statements for the year were presented by the Treasurer, Mr. E. H. Shaughnessy, and were adopted on the motion of Major H. Brown, seconded by Mr. A. O. Gibbon.

Colonel Purves then presented the following medals awarded for the Session 1923/24:—

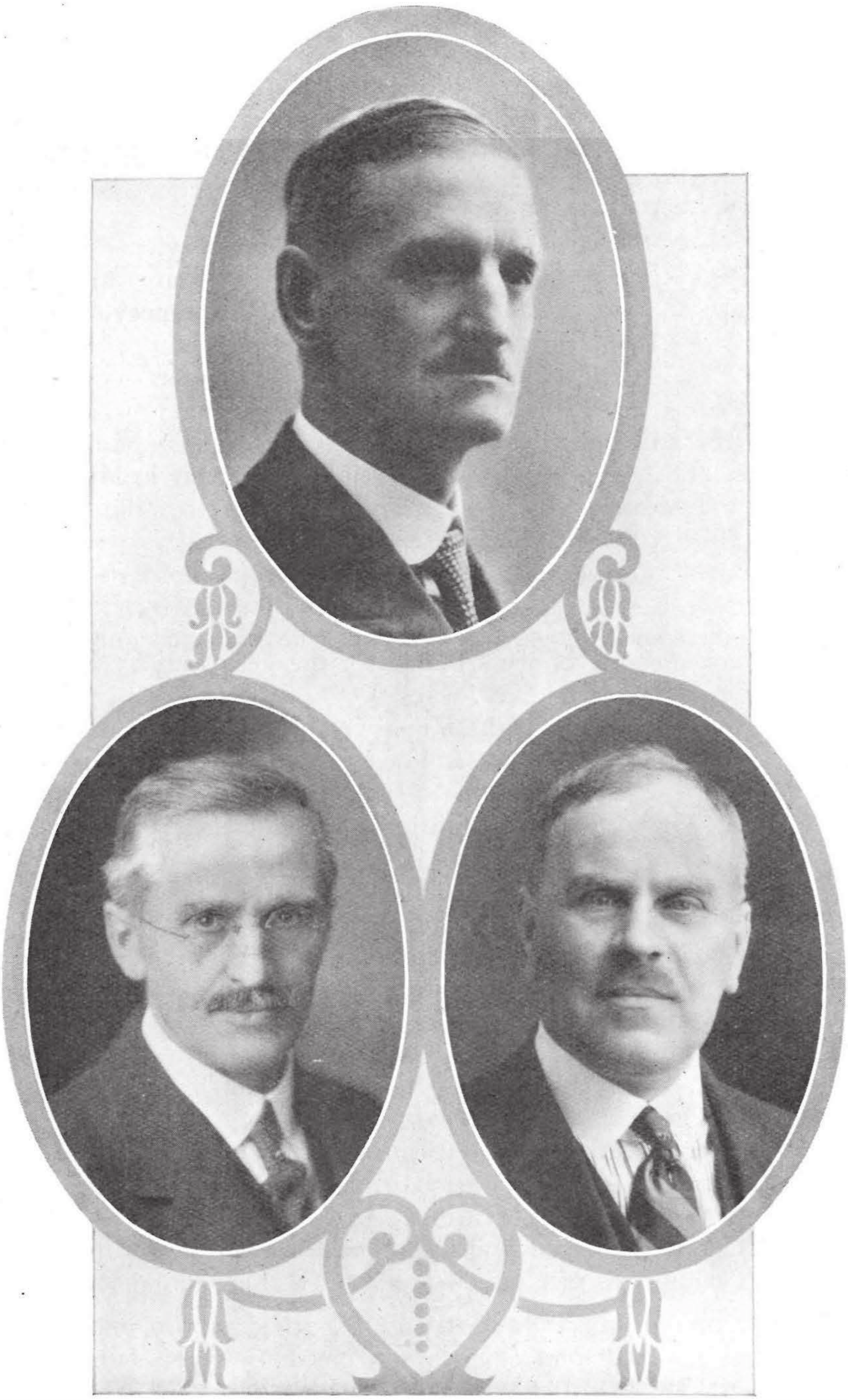
Senior Silver Medal to Capt. J. G. Hines for his paper on "Some considerations affecting the Lay-out of Telephone Plant in a Multi-Exchange Area."

Junior Silver Medals to Messrs. A. J. Pratt and G. H. A. Wildgoose for their joint paper on "The Economical Provision of Plant for Telephone Development."

A hearty vote of thanks, proposed by Mr. A. L. DeLattre, Vice-President, and seconded by Mr. A. J. W. Dauncey, was accorded to the retiring members of Council—Messrs. E. H. Shaughnessy, E. J. Wilby, W. H. Cresswell and R. Towers—for their services during the past three years.

The Council and Officers for the year 1925-6 are as follows:—

Chairman—Mr. A. L. DeLattre.
Representing Staff of the Engineer-in-Chief's Office:—
Mr. J. W. Atkinson and Mr. G. F. O'dell.
,, Executive Engineers—
London: Mr. A. Wright.
Provinces: Mr. F. W. Best.



THE INSTITUTION MEDALLISTS FOR SESSION 1923-4.
Senior Silver Medal : Captain J. G. Hines (top).
Junior Silver Medal : Messrs. A. J. Pratt (right) and G. H. A. Wildgoose.
(*Mr. Wildgoose's photo is by Guttenberg, Manchester.*)

Representing Assistant and Second Class Engineers—
London: Mr. W. Dolton.
Provinces: Mr. C. E. Morgan.
,, Chief Inspectors:
London: Mr. W. A. Romain.
Provinces: Mr. A. S. Carr.
,, Clerical Staff—
London: Mr. E. H. M. Slattery.
Provinces: Mr. T. E. Cramp and Mr. A. J. W. Dauncey.
,, Inspectors—
London: Mr. C. W. Messenger.
Provinces: Mr. R. P. Collins.
,, Draughtsmen—
London and Provinces: Mr. H. J. Millett.
Honorary Treasurer—Mr. B. O. Anson.
Secretary—Mr. R. V. Hansford.

COUNCIL NOTES.

The last meeting of the Council for the year 1924-25 was held in London on the 12th May.

The Council approved the Report of the Judges for the recent Essay Competition and the following is the order of the prize winners:—

1. F. J. Gibbs, Repeater Station, Marlborough.
   "Telephone Repeaters in Practice."
2. S. H. Johnson, External Section, Birmingham.
   "Fault Locating in Local Underground Cables."
3. A. F. Strudwick, Tunbridge Wells.
   "Small Matters that need Reform in the P.O.E.D."
4. H. S. Twort, Tunbridge Wells.
   "Making a Local Development Survey."
5. H. C. A. Linck, Internal Section, Cardiff.
   "The Extension of Large Multiples."

The Council authorised the printing of the following paper:—

"Siemens No. 16 Automatic Telephony Equipment," by C. W. Brown (E.-in-C.O.).

The Council received and approved the annual reports of the various Committees of Council and passed the Annual Report of the Council.

The first meeting of the Council for the year 1925-6 was held in London on the 12th May, 1925.

The Council elected the Committees of Council and re-appointed the officers for the ensuing year.

The Council discussed the proposed activities of the Institution for the ensuing session and, *inter alia,* decided to hold another Essay Competition for Workmen.

The probable financial results of the year's working were discussed, and an estimate of the revenue and expenditure for the year was approved.

LOCAL CENTRE NOTES.

LONDON CENTRE.

SESSION 1924-25—SECOND HALF.

Arrangements were made with the General Electric Co. for a visit to their Osram Lamp Works at Brook Green, Hammersmith. The number of members wishing to visit the works was so large that the Company kindly offered seven afternoons, taking a party of 32 on each occasion. The visit was much enjoyed and the Committee would like to take the opportunity of thanking the Managing Director and his staff for the personal interest taken in the matter.

On 13th January, 1925, Mr. J. S. Brown, M.I.E.E., read a paper on "Submarine Cable Work in Tidal Waters." An abstract of the paper appears in the April, 1925, number of this Journal.

On 10th February, 1925, Mr. W. S. Mountain gave a lecture on "Contracts." A synopsis of the lecture is given under the Northern Centre notes in the January, 1925, number of this Journal.

On 28th April, Mr. J. E. Statters read a paper on "Telephone Transmission." A brief outline of the scope of the paper is given in the South Midland Centre notes in the April, 1925, number of this Journal.

At the conclusion of the Annual General Meeting of the Institution on 10th May, Mr. F. O. Barralet, M.Inst. of Metals, A.M.I.E.E., read a paper on "Some Applications of Optical Methods to the Investigation of Engineering Materials." The author gave a brief description of the microscope and its accessories, the adaptation of the microscope to the examination of metals, and practical examples of its use; the Greenhough binocular microscope; the Quartz Spectrograph and its use in qualitative and quantitative analysis, and the specification of colour by means of the method of mono-chromatic analysis and the Nutting calorimeter.

An oustanding feature of the Session just closed was the inauguration of informal meetings. The Committee considered that the work of the Institution would be very usefully extended by holding such meetings, one of the principal objects being to encourage the younger members to take part in the discussions. The innovation has met with striking success. The application for short papers, occupying about a quarter of an hour to read, met with a ready response. The subjects selected were as follows :—

	Subject.	*Date.*
(1)	" Some aspects of Development Studies " ...	28-10-24
(2)	" The duties of Clerk of Works on Telephone Exchange Installations "	15-11-24
(3)	" Automatic Exchanges in Director Areas. Circuit and Operation of the Final Selector for P.B.X. groups, 2—10 lines "	16-12-24
(4)	" Wireless. Low Frequency Amplification "	20-1-25
(5)	" Fitting Work "	24-2-25

The average attendance was 52 and the interest shown in the discussions has been most encouraging. Informal meetings will form a definite part of the London programme in future. The expenditure incurred in connection with these meetings was quite small; any travelling expenses were borne by the members.

COMMITTEE FOR SESSION 1925-6.

Chairman : Mr. F. L. Henley.
Vice-Chairman : Mr. J. P. Price.

Headquarters Representatives :
Staff Engineers—Mr. P. T. Wood.
Clerical Staff—
Executive Engineers—
Messrs. W. Pennington and E. V. Smart.
Assistant Engineers—
Messrs. W. Dolton and A. J. Sharpley.
Chief Inspectors—
Messrs, J. Prescott and W. A. B. Romain.
Inspectors—
Messrs. W. H. Cresswell and D. C. D. P. Maddocks.
Draughtsmen—
Mr. H. Taylour.
London Clerical Staff—
Messrs. E. T. Larner and E. H. M. Slattery.

South Eastern District—
Engineering Staff—Mr. W. J. Jenkins.
Clerical Staff—Mr. P. J. Dodgson.

R.T.R.

SCOTLAND WEST CENTRE.

The final meeting for Session 1924-25 was held in the Royal Technical College, Glasgow, on 27th April, Capt. Crompton presiding.

After disposal of the business, appropriate to the Annual General Meeting, Mr. T. Bell delivered his lecture on "Cable Balancing" which was held over from January meeting.

At the outset the lecturer explained the necessity for cable balancing, and then explained the various steps taken in making the tests. Slides were shown illustrating the apparatus, cables, layout of plant, and schedules used in recording the results of the tests made preparatory to jointing. Interest was sustained throughout the lecture, and a very good discussion followed. The answers to questions were fully dealt with, and they provided further useful information on the subject.

SCOTLAND EAST CENTRE.

SESSION 1924-25.

The opening meeting of the Session was held at Edinburgh on the 19th November. A lecture on "Contracts" was delivered by Mr. W. S. Mountain, of the Engineer-in-Chief's Office. The subject was dealt with in a masterly manner and was followed by a most useful discussion.

The Lecturer's humorous vein enlivened the proceedings and eventually aroused the local wit, whose seidlitz powder fiz was irresistibly funny.

A hearty vote of thanks was accorded the lecturer for his very interesting, authoritative and informative lecture.

The second lecture which had been arranged had unfortunately to be postponed to another Session owing to the prolonged illness of the lecturer.

The third item on the programme was a paper entitled "Siemens No. 16 Automatic Telephone Equipment," by Mr. C. W. Brown, of the Telephone Section, Engineer-in-Chief's Office. The paper was illustrated by lantern slides and had been specially written for the Scotland East District. The subject was dealt with under the following heads:—

(1) Some features of the Switches and Banks.
(2) Messrs. Siemens Bros. diagram scheme and conventions used.
(3) The tones employed.
(4) Elements of the Main Circuits.
(5) Satellite Exchange arrangements.

(6) Testing and Trunk offering switches.
(7) Auxiliary signals and alarms, etc.

Messrs. Siemens Bros. & Company very kindly loaned a full working model, which was on exhibition at Wembley, and Mr. Long, of their Woolwich Staff came specially down to Edinburgh in connection with the lecture. His excellent demonstration was thoroughly enjoyed.

The discussion was opened by Mr. F. G. Milne, Secretary to the Post Office for Scotland, who expressed his pleasure at being present at the meeting, and spoke in eulogistic terms of the work of the Engineering Department.

Various points of interest were raised by other speakers and fully explained by Mr. Brown.

Mr. D. MacLachlan, in his inimitable way, moved a very hearty vote of thanks—

(1st) To Mr. Brown for his exceedingly interesting and instructive lecture, which had aroused the keenest interest and was rendered more valuable by the fact that the system was shortly to be installed at Edinburgh.
(2nd) To Mr. Long for his excellent demonstration.
(3rd) To Messrs. Siemens Bros, and Company for placing at the disposal of the Centre the Model Automatic Equipment and also the services of Mr. Long, at very considerable expense to themselves. Messrs. Siemens Bros. had also agreed to the continued loan of the demonstration equipment for educational purposes.

The audience included members of other Government Departments and outside Technical Bodies, and was the largest since the inception of the Institution.

Owing to the illness of Mr. J. E. Statters, after his arrival at Edinburgh, the arrangements made for his lecture on " Telephone Transmission " had perforce to be cancelled. The members had been eagerly looking forward to a lecture on this important subject, and it was with very great regret that they learned of Mr. Statters's indisposition.

The lecture, " Some Notes on the Edinburgh-Newcastle Main Underground Work," by Messrs. G. Innes, P. G. Martin and J. Gilbert, has also unavoidably been cancelled, Mr. Martin having been for some time in England undergoing a special course of training, and Mr. J. Gilbert, since his transfer to Edinburgh, had been fully occupied in connection with the extensive alterations at the Central Telephone Exchange. They had, therefore, been unable to devote the necessary time to the preparation of the papers.

The concluding meeting of the Session was held on 28th April, when Mr. J. W. Jarvis read a paper on " Main Cable Testing." The subject is one of especial interest at the present time and a vast amount of information was imparted by the lecturer in the time at his disposal. The various points dealt with were illustrated by an excellent series of lantern slides. A useful discussion followed, and the lecturer was complimented on the masterly manner in which he had dealt with the subject. A hearty vote of thanks was carried with acclamation.

NORTH WALES CENTRE.

The last meeting of the 1924-5 Session took place on 10th March, 1925, when " Transmission Efficiency of Telephone Circuits—External Plant " was dealt with by Messrs. W. C. Burbridge, A.M.I.E.E., and E. A. Pearson, A.M.I.E.E. Mr. T. Plummer, M.I.E.E., occupied the chair.

Mr. Pearson in introducing the subject dealt with line transmission and traffic circulation and the types of circuits required between (*a*) small exchanges and group centres; (*b*) group centres and zone centres, and (*c*) between different zone centres. He laid special emphasis upon the importance of avoiding even very short lengths of low gauge underground in zone centre circuits.

Mr. Burbridge's contribution dealt more specifically with the design of junction cables, and the difficulties met with in forecasting conductor requirements at the estimate stage in view of the unforeseen factors which frequently altered the whole aspect of a case.

An admirable discussion drew many interesting points, which were replied to by the lecturers.

The Session has been a most successful one both in the attendances at the meetings and in the quality of the papers presented, and it is satisfactory to know that a complete programme has already been arranged for the coming Session. The membership has been increased to 156, which represents 90% of the eligible number.

It is perhaps worthy of note in commenting on the progress of the Centre that the Chairman, Mr. T. Plummer, M.I.E.E., has only been absent from the Centre meetings on two occasions since he became Chairman in 1910.

It is pleasing to the members of the Centre to observe that the District was represented in the list of prize winners in the essay competition for workmen arranged by the Council, Mr. S. H. Johnson, of the Birmingham External Section, being successful with an essay on " Fault Locating in Local Underground Cables."

SOUTH MIDLAND CENTRE.

The concluding lecture of last Session, entitled "Aids to Efficiency," was given by Mr. W. Atkins, A.M.I.E.E., on the 25th March. The Lecturer stated that every worker, irrespective of his grade, had abundant opportunities for striving for maximum efficiency, and he considered that that desideratum is obtainable by the possession of a retentive memory, a sense of order and method, and an appreciation of perspective.

He enlarged upon the value of a good memory and explained how that gift could be improved by exercise. Muddle was condemned and a few useful general tips for ensuring order and method were described. The systematizing of correspondence was stressed and the filing arrangements adopted by the author were explained in some detail.

The importance of precision in correspondence was enlarged upon and the ludicrousness of the literal meaning of some amusing examples of loosely worded notices which are commonly displayed was greeted with laughter.

Mr. Atkins advocated the adoption of the key-coding system for correspondence emanating from larger offices, which arrangement, he claimed, would reduce delay.

The lecture concluded with a plea for broad-mindedness, initiative and courage and convincing illustrations were given of undesirable results obtained when these qualities were lacking or deficient.

Messrs. Peck, C. L. Perkins, Lines, Harris, J. S. Brown and the Chairman in turn expressed gratitude to the Lecturer for a paper which had shown them how to reduce their official cares, and Mr. Atkins replied to the questions asked.

The Chairman thanked Mr. Atkins for his paper, and the meeting concluded with the endorsing applause of the audience.

There was an average attendance of 58 at the six meetings of this Centre held last winter in the University College, Reading.

The Local Committee are pleased to announce that at the end of June there had already been a 30 per cent. increase in membership since the end of the 1924-5 Session and that a full and interesting programme for next Session has now been arranged.

A.W.L.

THOMAS PATTERSON.

THE Post Office Engineering Department has suffered a severe loss by the death of Mr. T. Patterson, Executive Engineer, London District, which took place on the 8th June. He had suffered from gastric trouble for some years, and although, latterly, it was realised that he was seriously ill, the end came with unexpected suddenness. He was 55 years of age.

Mr. Patterson entered the Post Office service in 1887 and served successively as Sorting Clerk and Telegraphist; Junior Clerk, Engineering Department; Sub-Engineer; 2nd Class Engineer; Assistant Engineer; and Executive Engineer. He was a man of generous impulse and wide sympathies, which were readily translated into practical expression when the occasion arose. The magnetism of his personality gained him a large circle of friends, which extended much beyond the confines of the Engineering Department. His geniality and goodwill were infectious—he radiated friendliness.

MR. THOMAS PATTERSON.

Apart from his attractive personal qualities, which alone would have sufficed to keep him in grateful memory, Patterson will be remembered as one of those who took a prominent part in the movement which resulted in the introduction of Whitleyism into the Civil Service, and the establishment of a separate Whitley Council for the Post Office Engineering Department. The report of the Government Committee presided over by Mr. Whitley, issued in the closing months of the war, stirred his imagination and fired his enthusiasm. Its appeal to representative men " with pride in their calling " to come together and apply themselves to promoting harmony and efficiency was like a clarion call to him and he threw himself heart and soul into the struggle to bring about the realisation in the Civil Service of the vision which the Whitley report had inspired. For, be it remembered, the Government of the day had no intention of applying the Whitley scheme to the Civil Service, and they gave way only after an intense campaign had demonstrated that the whole of the Civil Service was united in its desire to test the merits of the new scheme. Patterson was at this time Chairman of the Executive Committee of the Society of Post Office Engineers and he took a large part in the further struggle to gain recognition for the Engineering Department as a separate unit for Whitley purposes. When this had been successful he became the first Chairman of the Staff Side of the Engineering Departmental Whitley Council, an office which he held for two years. Perhaps his most important work during that period was his participation in the framing of the present recruitment scheme for the Post Office Engineering Department.

Patterson was an able member of his profession. To the tasks which confront the Sectional Engineer of to-day he applied himself with a characteristic zeal which was an inspiration to his staff. In the fateful days of the war he had to meet the exacting requirements in connection with the installation and maintenance of defence and other emergency communications (*e.g.*, those required between searchlight and gun stations in the sector of the London defences controlled by him), and subsequently he had taken his part in the solution of the general problem of how to meet the situation arising from the introduction of automatic telephones and the rapidly expanding development of the Service. In particular, he had a high conception of what was required of a Sectional Engineer in his dealings with the public: he stood for the principle of providing the very best service that could be given and no complaint ever came to his notice which was not treated from the standpoint that investigation might reveal a weakness in some part of the system which was impairing its efficiency.

G.B.

BOOK REVIEWS.

MR. HENRY FORD'S INDUSTRIAL PHILOSOPHY.

The last hundred years has seen this country and others transformed by what is termed industrialism and we have reached a period when all the methods by which industry has been carried on are being challenged.

The relative merits of the private business, the joint stock company and the State industry are discussed and yet economic theories are heard on every platform and published in all sections of the press.

This being the atmosphere surrounding our activities it is well for us at times to detach ourselves from our theoretical studies and seek a perspective which will enable us also to view the human and practical difficulties which beset us in every sphere of our commercial life.

The reading of Mr. Henry Ford's book " My Life and Work " is a valuable aid in enabling us to focus our attention on these problems in the light of the experience of one whose methods of business are being discussed the world over.

It may be urged that Motor Cars are not Telephones, and that Tractors are not Telegraphs, and that Post Office engineering, comprising as it does a widely scattered staff with an extensive administrative area, cannot be compared with centralised manufacturing plants such as that controlled by Mr. Ford. Whilst this may be true in many respects, it will be admitted, I think, that the views of any successful administrator regarding human tendencies and relationships as he sees them can usually be considered with profit.

Mr. Ford endeavours to upset many preconceived notions bearing on the conduct of business and time will show to what extent his philosophy is accepted.

Dealing with administration he says :—

> " That which one has to fight hardest against in bringing together a large number of people to do work, is excess organisation and consequent red tape. To my mind there is no bent of mind more dangerous than that which is sometimes described as the ' genius for organisation.' This usually results in the birth of a great big chart, showing after the fashion of a family tree how authority ramifies. The tree is heavy with nice round berries, each of which bears the name of a man or of an office. Every man has a title and certain duties which are strictly limited by the circumference of his being.
>
> " If a straw boss wants to say something to the general superintendent his message has to go through the sub-

> foreman, the foreman, the department head, and all the assistant superintendents before, in the course of time, it reaches the general superintendent. It is passed to and fro and all responsibility is dodged by individuals—following the lazy notion that two heads are better than one."

It may shock some people to learn that

> " It is not necessary to have meetings to establish good feeling between individuals or departments. It is not necessary for people to love each other in order to work together. Too much fellowship may indeed be a very bad thing, for it may lead to one man trying to cover up the faults of another. That is bad for both men."

Much has been done in recent years to reduce the number of titles in the Civil Service. It has undoubtedly added to the mobility of the staff, and in many ways led to more efficient and economical administration. It is, however, doubtful whether the advocates of reduction in or out of the Service would be prepared to endorse all that Mr. Ford has to say on this interesting subject.

> " The effect of a title is very peculiar. It has been used too much as a sign of emancipation from work. It is almost equivalent to a badge bearing the legend:
>
> " 'This man has nothing to do but regard himself as important and all others as inferior.'
>
> " Not only is a title often injurious to the wearer but it has its effect on others as well. There is perhaps no greater single source of personal dissatisfaction among men than the fact that the title-bearers are not always the real leaders. Everybody acknowledges a real leader—a man who is fit to plan and command. And when you find a real leader who bears a title you will have to enquire of someone else what his title is. He doesn't boast about it.
>
> " Titles in business have been greatly overdone and business has suffered. One of the bad features is the division of responsibility according to titles, which goes so far as to amount to a removal altogether of responsibility. Where responsibility is broken up into many small bits and divided among many departments, each department under its own titular head, who in turn is surrounded by a gang bearing their nice sub-titles, it is difficult to find any one who really feels responsibility.
>
> " A few titles may be legally necessary; a few may be useful in directing the public to do business with the concern, but for the rest the best rule is simple, 'Get rid of them.' "

Consolation will be carried to many readers by the following paragraph :—

> " Every business that is growing is at the same time

> creating new places for capable men. It cannot help but do so. This does not mean that new openings come every day and in groups. Not at all. They come only after hard work; it is the fellow who can stand the gaff of routine and still keep himself alive and alert who finally gets into direction. It is not sensational brilliance that one seeks in business, but sound substantial dependability. Big enterprises of necessity move slowly and cautiously. The young man with ambition ought to take a long look ahead and leave an ample margin of time for things to happen."

The tendency to slacken effort after a time and to rest on one's laurels is treated in characteristic fashion, and those who under pressure might admit the impeachment will be interested in Mr. Ford's views.

> "I noticed a tendency among many men in business to feel that their lot was hard—they worked against a day when they might retire and live on an income—get out of the strife. Life to them was a battle to be ended as soon as possible. That was another point I could not understand for, as I reasoned, life is not a battle except with our own tendency to sag with the downfall of 'getting settled.' If to petrify is success all one has to do is to humour the lazy side of the mind; but if to grow is success then we must wake up anew every morning and keep awake all day.
>
> "Even the man who feels himself 'settled' is not settled—he is probably sagging back. Everything is in flux and was meant to be. Life flows. We may live at the same number of the street, but it is never the same man who lives there.
>
> "It could almost be written down as a formula that when a man has at last found his method he had better begin a most searching examination of himself to see whether some part of his brain has not gone to sleep.
>
> "The man who is too set to change is dead already. The funeral is a mere detail."

As befits a man whose output of motor cars runs into thousands a day he has some pungent remarks to make regarding the purchasing power of the people and the methods of increasing the demand for a commodity.

> "If the prices of goods are above the incomes of the people then get the prices down to the incomes.
>
> "Get the costs down by better management. Get the prices down to the buying power. Cutting wages is the easiest and most slovenly way to handle the situation, not to speak of its being an inhuman way.
>
> "It is, in effect, throwing upon labour the incompetency

> of the managers of the business. If we only knew it, every depression is a challenge to every manufacturer to put more brains into his business—to overcome by management what other people try to overcome by wage reduction. To tamper with wages before all else is changed is to evade the real issue. And if the real issue is tackled first, no reduction of wages may be necessary. That has been my experience."

In several places Mr. Ford shows his disdain for various types of records, and it breaks out again in the following reference to experiments.

> "The factory keeps no record of experiments. The foreman and superintendents remember what has been done. If a certain method has formerly been tried and failed somebody will remember it—but I am not particularly anxious for the man to remember what someone else has tried to do in the past, for then we might quickly accumulate far too many things that could not be done. That is one of the troubles with extensive records. If you keep on recording all of your failures you will shortly have a list showing that there is nothing left for you to try—whereas it by no means follows because one man has failed in a certain method that another man will not succeed.
>
> "Then, too, a record of failures—particularly if it is a from trying. We get some of our best results from letting fools rush in where angels fear to tread."

Space will not permit an expression of opinion on the views contained in this remarkable book, but its perusal is well worth the time of anyone. There is much no doubt with which the reader will disagree, but he will be forced to admit that as far as achievement is concerned Mr. Ford has contributed something in his day and generation.

He has great confidence that the progress of the race is assured and that if true service is individually given "Everything is possible. . . . Faith is the substance of things hoped for, the evidence of things not seen."

The book is in the Institution Library.

A.J.W.D.

"Der Fernsprechverkehr als Massenerscheinung Mit Starken Schwankungen." By Dr. G. Rückle and Dr.-Ing. F. Lubberger.

Here at last is a book on telephone traffic, more particularly with reference to automatic exchanges. It has long been a matter for regret that this subject has received such scant attention in the published literature of automatic telephony. It would be possible to criticise the present work from the opposite standpoint, for, while there is great need for a book dealing comprehensively with automatic trunking, Dr. Rückle and Dr. Lubberger have confined themselves almost exclusively to the theoretical side of the subject. References to checks on theoretical results by actual traffic observations are meagre and no description is given of the means provided for carrying out trunking work in actual exchanges. While it is perhaps ungracious thus to criticise the scope of the work, it is felt that an extension of that scope would have made the book useful to a wider circle of readers.

On the theoretical side of the subject, however, the book is admirable. The authors are well known as having made notable and original contributions to the subject, but in this work full publicity is given to the contributions of other investigators, including numerous references to the published works of these investigators. It is thus possible from the present volume alone to gain a good idea of the present position of this fascinating subject.

After a few introductory pages, the authors develop the fundamental equations giving the relation between number of switches or circuits occupied and amount of traffic. They then develop the idea of lost traffic and proceed to estimate its amount. The influence on the fundamental equations of certain magnitudes, such as the number of subscribers, is then discussed. In later sections the traffic carried by each individual switch in a group, the effect of abnormal call durations, and other matters are dealt with.

Finally, a method of estimating the traffic capacity of gradings is developed. It is interesting to note that this method is similar to one which was under consideration in this Department some years ago and was actually under test at the time when the present work was being read for review.

It is not surprising to find a few misprints in a work of this nature. Thus the letters used for distinguishing the various curves in Fig. 10 do not agree with those in the text.

The value of the work is materially increased by a good bibliography containing 34 references. Half of these are to various German publications. The 10 English references are all to our own Journal, for the issues of Oct. 1910, April 1915, Jan. and Oct. 1918, Oct. 1920, Jan., April and July 1922, Oct. 1923, Jan. and April 1924. The remaining references are to American, Danish, Dutch, French, and Italian sources.

Even if it is not possible to agree to all the conclusions of the authors there is no doubt that the book goes far to satisfy a need which has long been acute.

G. F. O'DELL.

"The History of the Telephone in the United Kingdom." By F. G. C. Baldwin. Chapman & Hall, Ltd. £2 2s. 0d. net.

Not only the author, but the publishers are to be congratulated on the production of this book. It contains over 700 pages of most absorbing matter together with nearly 200 excellent illustrations.

There are many of us in the telephone business in Great Britain who are optimistic enough to think that a wave of great development is before us, and although the vicissitudes of the past have had a seriously retarding effect, we think that they were difficulties of policy that have now come to an end and that in this country, as in others, we can now quote as our motto *One Policy, One System, Universal Service.*

As regards Mr. Baldwin's book, we think that it would be difficult to give a more appropriate review than to quote, *in extenso,* the foreword to the volume which is contributed by Mr. F. Gill, Past President of the Institution of Electrical Engineers, and we make no apology for doing so.

Mr. Gill says:—

> "Every telephone man, and many others, will feel an immense debt of gratitude to Mr. Baldwin for this fine piece of research into the history of the telephone, primarily in this country, but with many sidelights on similar history in the United States. It must indeed have been no light task which he took up, and while it is likely that in such a multitude of detail there may well be some errors, yet I believe these are few and that a second edition will see them, if they exist, eliminated.
>
> "The history of the telephone is the history of a very important movement; man isolated and by himself is impotent and defenceless—in association with others of his kind, on the contrary, he is capable of much, and a primary condition for this association is communication. First, speech, limited to a few yards distance; then writing, which extended the distance while imposing a call for learning; then printing, with its facility for the increased distribution of communication; later telegraphy by visual signals, then the electric telegraph—virtually writing at a distance; then, from 1876, telephony gradually abolished the distance limitation to speech, so that now it is technically possible to construct telephone circuits over any land distance on the earth, and to operate them between centres of population at prices which people are willing to pay. Telephony has some of the properties both of the letter and of the newspaper; it can be clothed with privacy, given to one individual only, or it can be broadcast to millions simultaneously. Starting on a strictly local basis it spread

until now it covers the whole country, and, extending still further, is beginning to develop into a system for intimate communication between individuals of different nationalities. The end is inevitable. Each system of any credit will have good communication between all its stations; there will also be good communication between systems—hence any station on such system will be able to have speech with any other, bearing in mind that probably there will always be some stations which are not intended to have a radius of action of more than a very limited extent. But a great deal has yet to be done before this end is achieved as regards Europe, the immediate field. With so many nationalities responsible for the telephone service, the matter is one which has many political aspects, and these, if allowed to have undue influence, may well jeopardise the efficiency of the communication system. The technical men have been ready since the termination of the war; it remains for the business men to arrange an efficient organisation. When that has been effected there can be quick, reliable service given between all the centres of population in Europe desiring it. In the absence of an efficient organisation, a lame, inefficient, second-rate kind of service is all that can be expected; one in which the transmission is poor, the delays in completing connections are very long and many calls cancelled because of the delays; these are all marks of lack of grip in the International service; the price is a secondary matter, the really important things are accuracy, speed and quality. Upon how this organisation is worked out will depend the verdict upon the labours of the Consultative Committee for International Telephony in Europe.

"But comparative telephone history has another aspect which is of interest and indeed of importance. It was a pioneer industry when it started; no one then knew if it would succeed. Would the public take to it? Would they continue to use it? What would be the cost of running it? All these questions and many more were at that time unanswered, and the men who risked their money and time in starting this pioneer business which was to prove of such immense value to mankind, had as backing, only that which they received from their faith; they got none from their country. Readers of this book will learn something, but not all, of the difficult and harassing conditions under which these pioneers worked, and will realise something of the reason for the backwardness of this country in the use of telephone service.

"Some of the history of the telephone in the United Kingdom for the period 1904-1912 has not yet been written, perhaps never will be; but it is no reflection upon Mr. Baldwin's book that there should be certain gaps in the history he narrates; these matters were known to few, and death has removed a number of those intimately concerned.

" There is much in this book of great interest, but I think it has, to the student of social history, a value possibly even greater than to the student of telephony."

B.O.A.

" Principles of Transmission in Telephony." By M. P. Weinbach, A.B., B.S. in E.E., A.M. Pp. xiv. × 303. The Macmillan Co. Price 17*s*. net.

This book is designed as a text-book for students of electrical engineering. It gives a thorough and straightforward development of the theory of telephonic transmission.

The first three chapters give an introduction to the subject and an outline of the mathematical methods employed, including representation of harmonic functions, Fourier analysis, vector operations and hyperbolic functions.

In Chapter 4 are developed the general equations of electric wave propagation along lines. Data are given for a number of types of telephonic circuits and the method of calculating the transmission constants is illustrated in the case of a No. 10 B. & S. aerial line. In this example and throughout the book it is assumed that a voltage of 50 at a frequency of 796 cycles per sec. is applied to the line. Voltages such as this do not occur in practice, especially when applied to a line containing amplifiers, as is assumed later on in the book. It would be preferable to take a more usual value, such as 2 volts, in order to avoid misleading readers who are not familiar with practical telephone work.

Chapters 5, 6, 7 and 8 deal with the application of the theory to special cases, viz., infinitely long circuits and circuits with the distant end open, short-circuited or closed by an impedance. Chapter 6 deals with the " Ferranti " effect, which is of especial interest in connection with power lines.

Chapter 9 deals with power transfer and reflection phenomena. In this chapter the mechanism of the transfer of energy between electric and magnetic forms is discussed. Perhaps the statement on p. 102, that the velocity of propagation $\sqrt{\frac{1}{LC}}$ is equal to that of light, should be limited to the case of unloaded aerial lines. It does not even approximately apply to cable circuits.

Chapter 10 deals with power relations in lines. Such problems as the question of the most suitable impedance for receiving instruments are dealt with.

Chapter 11 deals fully with the equivalent circuit, *i.e.,* the representation of actual circuits by means of comparatively simple impedance networks.

Chapter 12 deals with distortion of telephonic speech due to the variations of line impedance, attenuation and velocity of propagation with frequency. The conditions for distortionless transmission are obtained. This leads up to Chapter 13, which deals with loaded circuits. The effects of lumping the load is considered and a number of examples are worked out.

Chapters 14 and 15 deal with amplifiers and their application to lines. This is now a wide subject and only an outline of it can be given in the space available. The particulars given of the "standard amplifying tube" do not compare favourably with the British P.O. valve used on telephone repeaters.

Chapter 16 deals with the impedance of lines and its measurement. The effect of irregularities upon the smoothness of the impedance-frequency curve is discussed. The use of balancing net works is mentioned, but no details of the method of design are given.

Chapter 17 deals with transmission equivalents, including the standard cable and the "TU." The methods of making transmission measurements with the voice and with transmission measuring sets is described. The method of making speech tests described on p. 275 would, it is thought, give very unreliable results.

The book terminates with a short bibliography.

Noticeable omissions from the book are the subjects of transient phenomena and harmonic filters, both of which are of practical importance in modern telephony.

The great merit of the book is the clear and logical manner in which the theory is worked out from fundamental principles. The printing and diagrams are excellent. The book can be strongly recommended both to students and to electrical engineers.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
Wilson, R.	Executive Engineer, E.-in-C. Office.	Asst. Superintending Engineer, London District.	17-5-25
Brocklesby, C.	Assistant Engineer, N. Wales District.	Executive Engineer, S. Lancs District.	1-4-25
De Wardt, R. G.	Assistant Engineer, (Tempy. O/C. Oxford Wireless Station).	Executive Engineer, In Charge Oxford Wireless Station.	1-4-25
Glover, J. B.	Assistant Engineer, N. West District.	Executive Engineer, Scot. East District.	31-5-25
Bufton, C. W. M.	Chief Inspector, S. East District.	Asst. Engineer, S. West District.	1-5-25
Davis, H.	Chief Inspector, Testing Branch.	Asst. Engineer, E.-in-C. Office.	12-4-25
Flanagan, F.	Chief Inspector, N. Wales District.	Asst. Engineer, N. Wales District.	19-4-25
Cox, W. S.	Chief Inspector, N. Mid. District.	Asst. Engineer, N. Mid. District.	7-4-25
Hamilton, W. D.	Chief Inspector, E.-in-C. Office.	Asst. Engineer, E.-in-C. Office.	19-4-25
Blake, Capt. E. C.	Chief Inspector, Testing Branch.	Asst. Engineer, E.-in-C. Office.	19-4-25
Hebden, E. D.	Chief Inspector, E.-in-C. Office.	Asst. Engineer, E.-in-C. Office.	To be fixed later.
Cory, B. G.	Chief Inspector, Met. Power District	Asst. Engineer, S. Wales District.	7-5-25
Evans, G. T.	Inspector, E.-in-C. Office.	Asst. Engineer, E.-in-C. Office.	To be fixed later.
Kennard, T. G.	Inspector, E.-in-C. Office.	Chief Inspector, E.-in-C. Office.	29-1-25
Irwin, A	Inspector, E.-in-C. Office.	Chief Inspector, E.-in-C. Office.	29-1-25
Moller, P. D.	Draughtsman. Cl. I., E.-in-C. Office.	Chief Inspector, E.-in-C. Office.	29-1-25
Towers, R.	Draughtsman, Cl. II. S. Lancs. District.	Chief Inspector, E.-in-C. Office.	To be fixed later.
Gusterson, H. N.	Draughtsman, Cl. I., E.-in-C. Office.	Senior Draughtsman, E.-in-C. Office.	11-9-24
Willmot, A. S.	Draughtsman, Cl. I. E.-in-C. Office.	Senior Draughtsman, E.-in-C. Office.	11-9-24
Blackstaffe, H. P.	Draughtsman, Cl. I. E.-in-C. Office.	Senior Draughtsman, E.-in-C. Office.	11-9-24
Lucena, H. J.	S.W.1.	Inspector, N. Wales District.	5-1-25
Hassall, W. H.	S.W.1.	Inspector, N. Wales District.	25-8-24
Stockton, A.	S.W.1.	Inspector, N. Wales District.	5-1-25
Kendall, C. A.	S.W.1.	Inspector, N. Wales District.	5-3-23
Harman, W. J.	S.W.1.	Inspector, N. Wales District.	25-8-24
Inscoe, E. S.	S.W.1.	Inspector, N. Wales District.	5-1-25
Wordley, C. H.	S.W.1.	Inspector, N. Wales District.	25-8-24
Sursham, H. D.	S.W.1.	Inspector, East District.	6-11-23

STAFF CHANGES.

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Tansley, L. W	S.W.1.	Inspector, East District.	13-6-24
Castle, H. V.	S.W.1.	Inspector, East District.	5-1-25
Ilett, J. E. W.	S.W.1.	Inspector, East District.	5-1-25
Batch, G. B.	S.W.1.	Inspector, East District.	16-2-25
Jones, C. J.	S.W.1.	Inspector, East District.	6-2-25
Guest, F.	S.W.1.	Inspector, East District.	4-2-25
Smithson, W.	S.W.1.	Inspector, N.E. District.	28-12-24
Shaw, J. W.	S.W.1.	Inspector, N.E. District.	14-12-24
Vear, F.	S.W.1.	Inspector, N.E. District.	15-3-25
Kershaw, S.	S.W.1.	Inspector, N.E. District.	1-10-24
Robinson, P.	S.W.1.	Inspector, N.E. District.	4-3-25
Keighley, A.	S.W.1.	Inspector, N.E. District.	4-3-25
Greene, A. H.	S.W.1.	Inspector, N.E. District.	3-3-25
Livingstone, J.	S.W.1.	Inspector, Scot. W. District.	21-12-24
Wells, R.	S.W.1.	Inspector, Scot. W. District.	21-12-24
Brown, A.	S.W.1.	Inspector, Scot. W. District.	22-12-24
Sutherland, A.	S.W.1.	Inspector, Scot. W. District.	15-9-24
Gayes, W. E.	S.W.1.	Inspector, Met. Power District.	8-10-23
Sturgess, H. E.	S.W.1	Inspector, E.-in-C. Office.	7-2-25
Hodge, G. W.	S.W.2.	Inspector, E.-in-C. Office.	7-2-25
South, W. B.	Inspector,	Inspector, N.Wa. Dist., resumed from Nigeria.	9-3-25
Laidler, W.	S.W.2	Inspector, Northern District.	5-1-25
Worthington, C. E.	S.W.2.	Inspector, Northern District.	5-1-25
Smith, J.	S.W.2.	Inspector, Northern District.	5-1-25
Dean, W. J.	S.W.1.	Inspector, N. Mid. District.	25-2-25
Wilcock, J.	S.W.1.	Inspector, N. West District.	5-1-25
Minshall, G. W.	S.W.1.	Inspector, N. West District.	29-3-25
Leyland, T.	S.W.1.	Inspector, N. West District.	29-3-25
Baldwin, F.	S.W.1.	Inspector, N. West District.	5-1-25
Wiper, H. S.	S.W.1.	Inspector, N. West District.	25-2-25
Megson, F. W.	S.W.1.	Inspector, N. West District.	5-1-25
Thompson, W. H. S.	S.W.1	Inspector, London District.	7-4-25

STAFF CHANGES.

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Harris, W. J.	S.W.1.	Inspector, S. Wales District.	5-1-25
Plummer, E. S	S.W.1.	Inspector, S. West District.	5-1-25
Seward, W. J.	S.W.1.	Inspector, S. West District.	5-1-25
Roach, H. C.	S.W.1.	Inspector, S. West District.	5-1-25
Brown, R. C. C.	S.W.2.	Inspector, S. West District.	5-1-25
Pilsbury, J. H.	S.W.1.	Inspector, S. Lancs. District.	5-1-25
Payne, C. F.	S.W.1.	Inspector, S. Lancs. District.	5-1-25
Moon, F. H.	S.W.1.	Inspector, S. Lancs. District.	5-1-25
Warburton, T. E.	S.W.1.	Inspector, S. Lancs. District.	14-12-24
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Harrison J.	S.W.1.	Inspector, S. Lancs. District.	5-1-25
Jones, W.	S.W.1.	Inspector, S. Lancs. District.	25-8-24
Tansley, W.	S.W.1.	Inspector, S. Lancs. District.	25-8-24
Cleary, H.	S.W.1.	Inspector, S. Lancs. District.	1-1-25
Hibbert, J., Sr.	S.W.1.	Inspector, S. Lancs. District.	25-8-24
Lythoge, W. J.	S.W.1.	Inspector, S. Lancs. District.	25-8-24
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Davies, R. C.	S.W.1.	Inspector, S. Lancs. District.	7-12-24
Phipps, A.	S.W.1.	Inspector, S. Mid. District.	5-1-25
Stephens, H. N.	S.W.1.	Inspector, S. Mid. District.	5-1-25
Naylor, W. H. G.	S.W.1.	Inspector, S. Mid. District.	5-1-25
Gibbs, F. J.	S.W.1.	Inspector, S. Mid. District.	5-1-25
Brown, E. P.	S.W.1.	Inspector, S. Mid. District.	5-1-25
Tomkins, G. E.	S.W.1.	Inspector, S. Wales District.	1-4-25
Mann, F.	S.W.1.	Inspector, East District.	18-3-25
Owen, J. McA.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
Wylie, T. O. K.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
King, A. G.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
Smith, H. S.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
Paul, F. M.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
Rogers, H.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25

STAFF CHANGES.

PROMOTIONS.—continued.

Name.	Grade	Promoted to.	Date.
Limb, F.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
Smith, S. J.	Probationary Inspector.	Inspector, E.-in-C. Office.	1-4-25
Wilson, G.	Probationary Inspector.	Inspector, S. Wales District.	1-4-25
McKie, A. N.	Telegraphist.	Repeater Officer Cl. II., S.W. Dist.	1-1-25
Bulman, G. R.	Telegraphist.	Repeater Officer Cl. II., S.W. Dist.	1-1-25
		Appointed to	
Wright, J. S.	Probationary Inspector.	Testing Branch.	26-4-25
Spears, G.	Probationary Inspector.	E.-in-C. Office.	26-4-25
Casterton, E. J.	Probationary Inspector.	E.-in-C. Office.	26-4-25
Chapman, F. B.	Probationary Inspector.	E.-in-C. Office.	4-5-25
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Miller, G. S.	Probationary Inspector.	Testing Branch.	10-5-25
Gill, F. W.	Probationary Inspector.	Testing Branch.	12-5-25
Riley, C.	Probationary Inspector.	Testing Branch.	12-5-25
Creighton, J. L.	Probationary Inspector.	Testing Branch.	15-5-25
Folkard, G. F.	Probationary Inspector.	Testing Branch.	18-5-25
Hedley, D. J.	Probationary Inspector.	Testing Branch,	18-5-25
Affleck, D. B.	Probationary Inspector.	E.-in-C. Office.	20-5-25
Clark, H. V.	Probationary Inspector.	E.-in-C. Office.	23-5-25
Stanesby, H.	Probationary Inspector.	E.-in-C. Office.	24-5-25
Ching, E. A.	Probationary Inspector.	Testing Branch, Provs.	25-5-25
Chapman, R. H.	Probationary Inspector.	Testing Branch, Provs.	25-5-25
Thorn, D. A.	Probationary Inspector.	Testing Branch, Provs.	25-5-25
Knee, H.	Probationary Inspector.	Testing Branch, Provs.	27-5-25
Duff, J.	Probationary Inspector.	E.-in-C. Office.	2-6-25

STAFF CHANGES.

APPOINTMENTS.

Name.	Grade.	Appointed.	Date.
Millard, C. W.	Probationary Assistant Engineers.	Assistant Engineers.	1-4-25
Tolley, L. L.	,,	,,	,,
Mumford, A. H.	,,	,,	,,
Epps, H. F.	,,	,,	,,
Carter, F. C.	,,	,,	,,
Ashdown, H. A.	,,	,,	,,
Smith, W. F.	,,	,,	,,
Parsons, R. A. E.	,,	,,	,,
Gracie, A. J. A.	,,	,,	,,

TRANSFERS.

Name	Grade.	Transferred.		Date.
		From	To.	
Fleetwood, H. O.	Asst. Engineer.	S. Wales Dist.	Met. Power District.	3-5-25
Smith, W. F.	Asst. Engineer.	E.-in-C. Office.	Oxford W .S.	1-4-25
Halton, E.	Asst. Engineer.	N. Wales Dist.	N. West Dist.	1-6-25
West, A. S.	Inspector.	Oxford Radio.	E.-in-C. Office.	16-4-25

RETIREMENTS.

Name	Grade.	District.	Date.
Stanhope, J. H.	Asst. Suptg. Engr.	London.	30-4-25
Jeffreyes, G. C.	Executive Engineer.	Scotland East.	1-5-25
Roberts, A. H.	Executive Engineer.	E.-in-C. Office.	31-3-25
Blomley, C.	Assistant Engineer.	North Midland.	30-4-25
James, J.	Assistant Engineer.	South Wales.	25-5-25
Day, T. F.	Assistant Engineer.	E.-in-C. Office.	11-4-25
McCloskey, A. E.	Chief Inspector.	London.	16-5-25
Pendreigh, W.	Inspector.	London.	9-5-25

RESIGNATIONS.

Name.	Grade.	Office.	Date.
Reyner, J. H.	Probationary Assistant Engineer.	E.-in-C. Office.	30-6-25

DEATHS.

Name.	Grade.	District.	Date.
Barnard, W. T.	Inspector.	London.	6-4-25

STAFF CHANGES.

CLERICAL ESTABLISHMENT.

PROMOTION.

Name.	Grade.	Promoted to	Date.
Crotch, A.	Executive Officer, E.-in-C. Office.	Higher Exec. Officer, E.-in-C. Office.	16-3-25

APPOINTMENTS AS CLERICAL OFFICER.

Name	District.	Date.
McHugh, C. J.	S. Lancs.	1-3-25
Thomson, J. A. McA. ..	E.-in-C.O.	29-3-25
Clarke, C. E.	E.-in-C.O.	29-3-25
Watts, A. W.	London	2-4-25
Granville, H. G.	E.-in-C.O.	19-4-25
Hannaford, E. J. G. ...	E.-in-C.O.	19-4-25
Hopewell, J. W.	N. Midland	26-4-25
Davies, W. M.	S. Lancs.	1-5-25
Ballard, W. S.	E.-in-C.O.	3-5-25

TRANSFERS.

Name.	Rank.	Transferred.		Date.
		From.	To.	
Eaton, J. C. ...	Higher Clerical Officer.	Eastern Dist.	S. Mid. Dist.	5-4-25
Cunliffe, L. ...	Clerical Officer.	Ministry of Pensions.	S. Lancs. Dist.	12-1-25
Nobles, E.	,,	N. Mid. Dist.	Rugby Radio Station.	11-3-25
Seward, V. J. ...	,,	Surveyor's Office, N. Wales Dist.	S. East Dist.	15-3-25
Bailey, R. H. B....	,,	Ministry of Pensions.	S. Wales Dist.	15-3-25
Giles, C. R. ...	,,	,,	,,	15-3-25
Kedzlie, J. A. ...	,,	,,	,,	15-3-25
Blake, J. S. ...	,,	,,	,,	26-3-25
Hawtin, W. J. ...	,,	,,	,,	26-3-25
Tarrant, J. A. ...	,,	,,	,,	26-3-25
Randall, F. W. ...	,,	,,	S. West Dist.	26-3-25
Jessop, R. H. ...	,,	Savings Bank Department.	E.-in-C. Office.	22-3-25
Holt, H. V. ...	,,	N. Wales Dist.	S. East Dist.	5-4-25
Ough, C.	,,	Air Ministry.	S. West Dist.	5-4-25
McIntyre, G. J. ...	,,	Scot. West District.	Nat. Insurance Audit Dept.	1-5-25
Crompton, C. H....	,,	Ministry of Pensions.	S. Lancs. Dist.	1-5-25
Harrison, E. ...	,,	London Dist.	N. Mid. Dist.	3-5-25
Lubertz, C. ...	,,	E.-in-C. Office.	L.P.S.	24-5-25

STAFF CHANGES.

OTHER CHANGES.

Name.	Rank.	District.	Cause.	Date.
Pestell, G. ...	Higher Clerical Officer.	S. West.	Superannuation	2-4-25
Holman, A. R. ...	Clerical Asst.	S. Mid.	,,	19-5-25
Sweeney, P. ...	Clerical Officer.	S. Lancs.	,,	20-5-25
Keane, W. ...	,,	London.	Decease.	17-5-25
Terry, R. V. H. ...	,,	E.-in-C. Office.	Appointed Asst. Surveyor, Posts & Tghs. Nigeria	29-4-25

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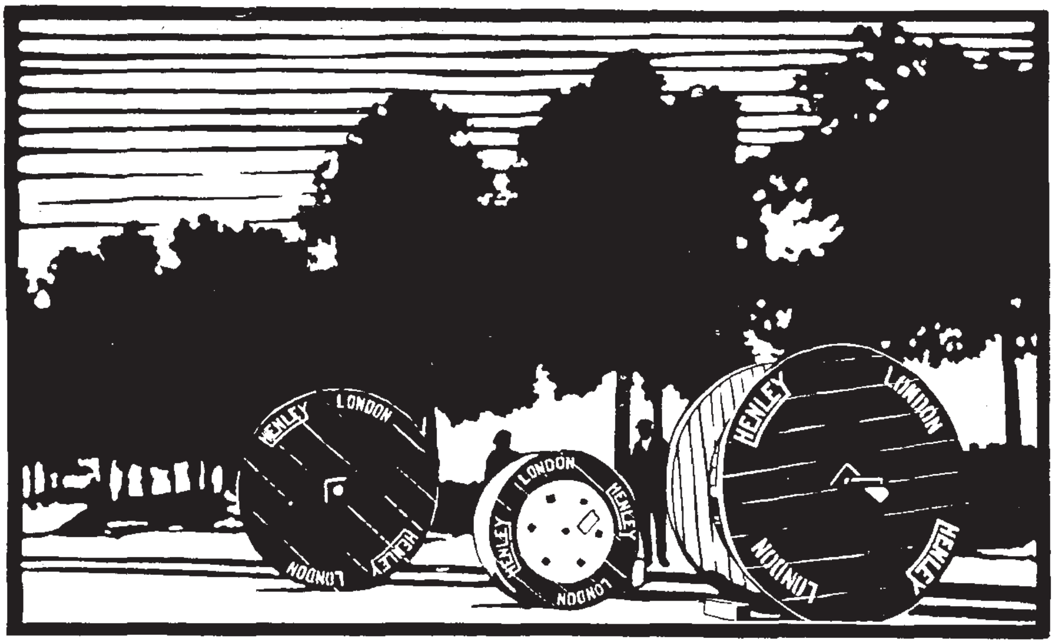

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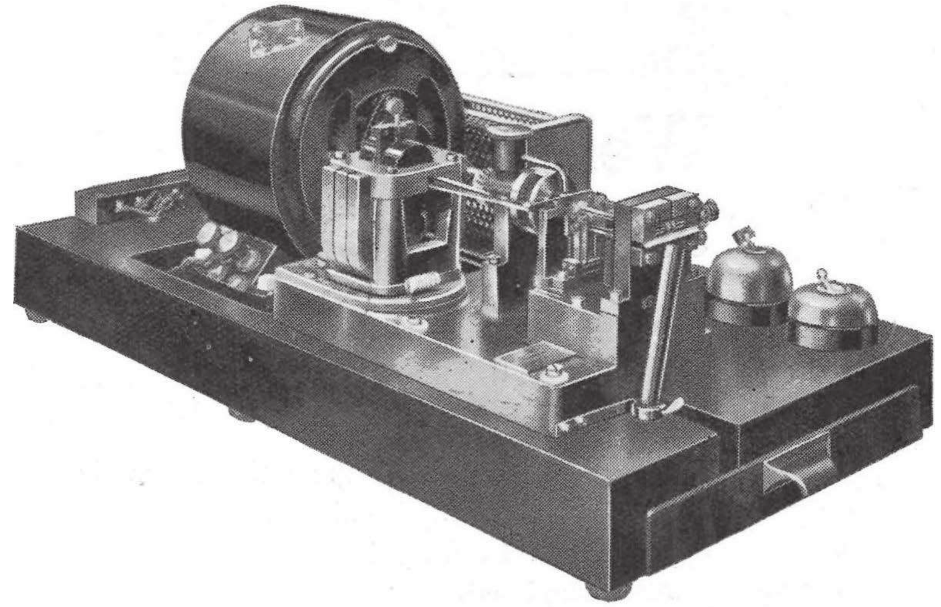

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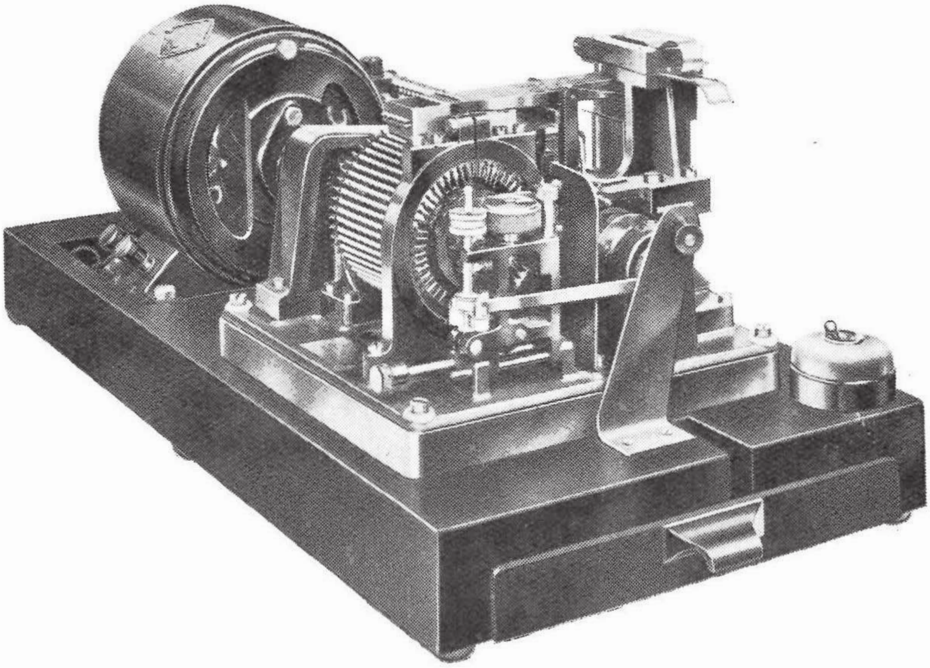

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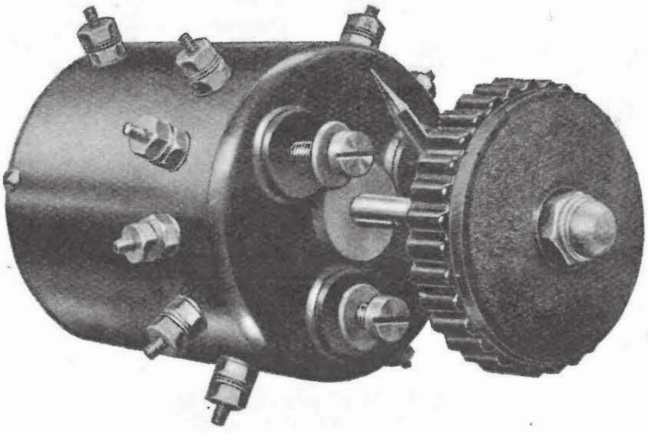

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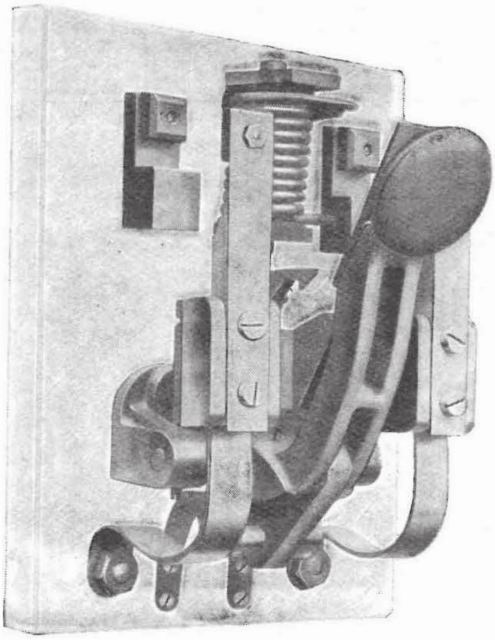

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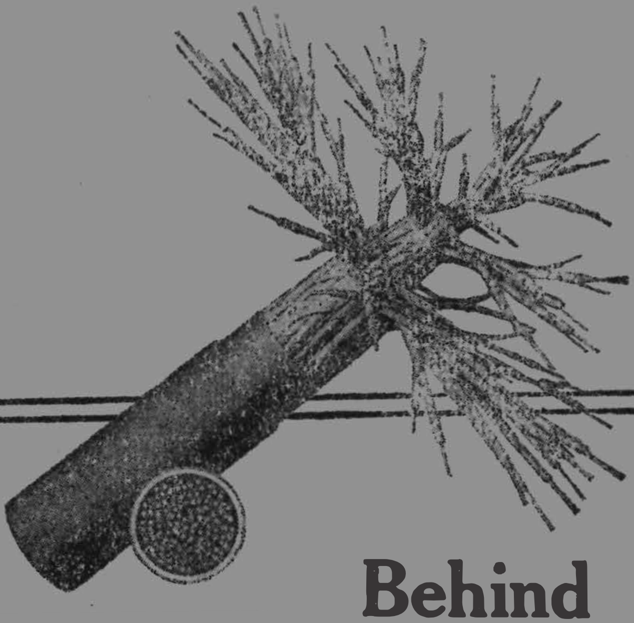

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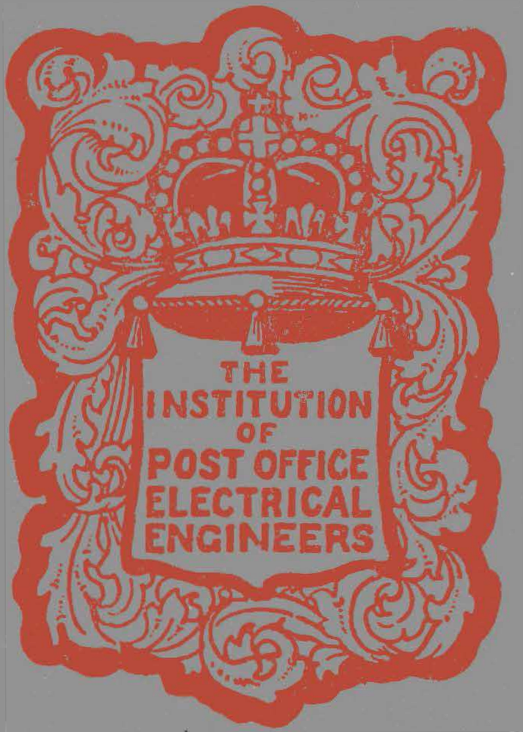

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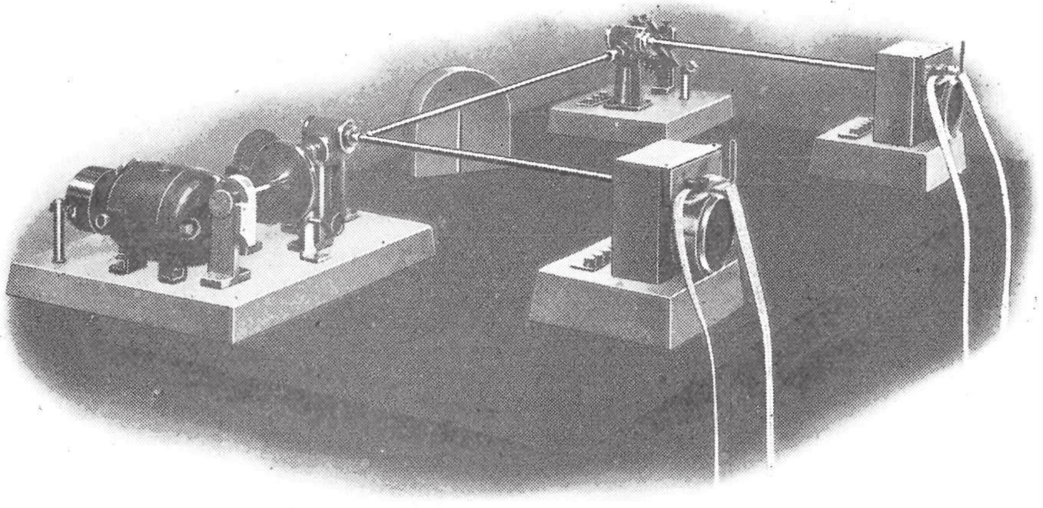

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PAGE
A VOICE FREQUENCY TELEGRAPH SYSTEM—W. D. HAMILTON 213
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM ... 225
JUNCTION WORKING BETWEEN AUTOMATIC AND MANUAL EXCHANGES. NON-DIRECTOR AREAS—I. H. JENKINS, A.M.I.E.E., and J. S. PATERSON 226
PORT OF LONDON AUTHORITY: PRIVATE AUTOMATIC BRANCH EXCHANGES—ALEC. B. EASON, M.A., A.M.I.C.E. 247
A MODERN TELEPHONE REPEATER STATION 260
GROWTH AND FINANCE OF THE POST OFFICE TELEPHONE SERVICE —W. J. MEDLYN, M.I.E.E. 291
FEDERATED MALAY STATES 296
NOTES AND COMMENTS 299
HEADQUARTERS NOTES 306
LONDON ENGINEERING DISTRICT 307
A NEW USE FOR AERIAL STAY WIRES 311
BOOK REVIEWS 311
BOOKS RECEIVED 312
PAPERS RECEIVED 312
STAFF CHANGES 313
COMMUNICATIONS 318
THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS ... 319

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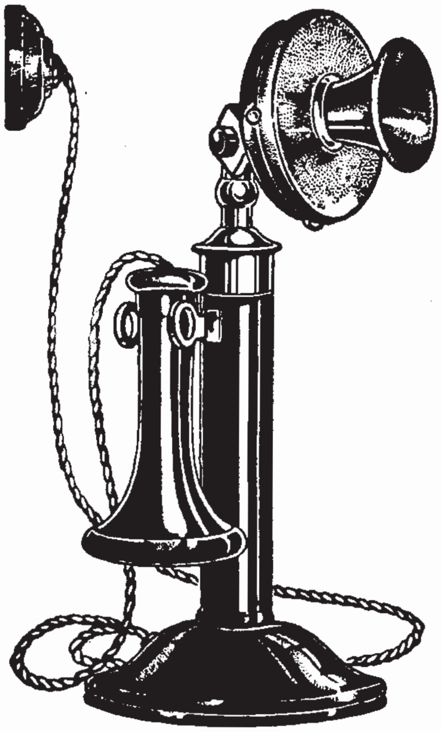

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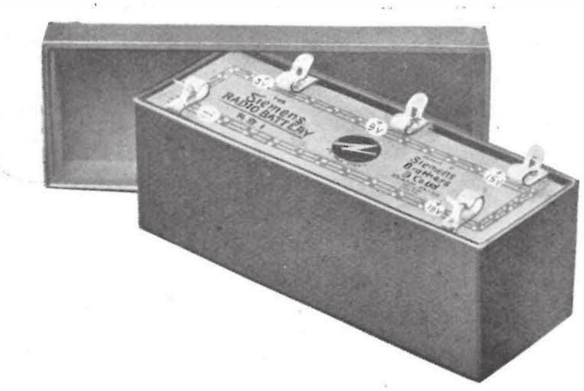

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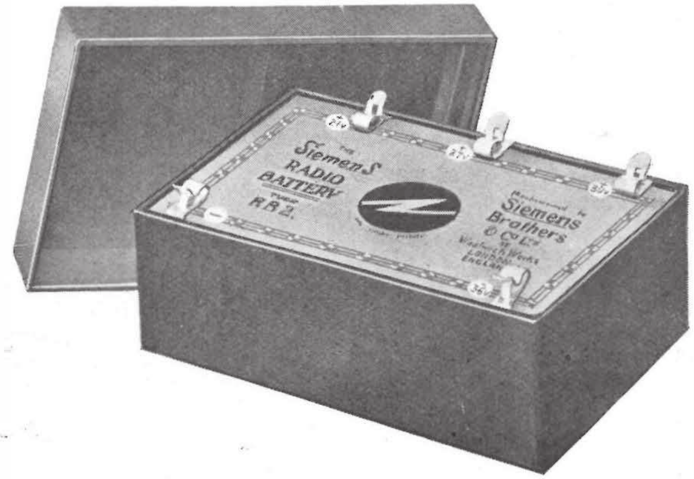

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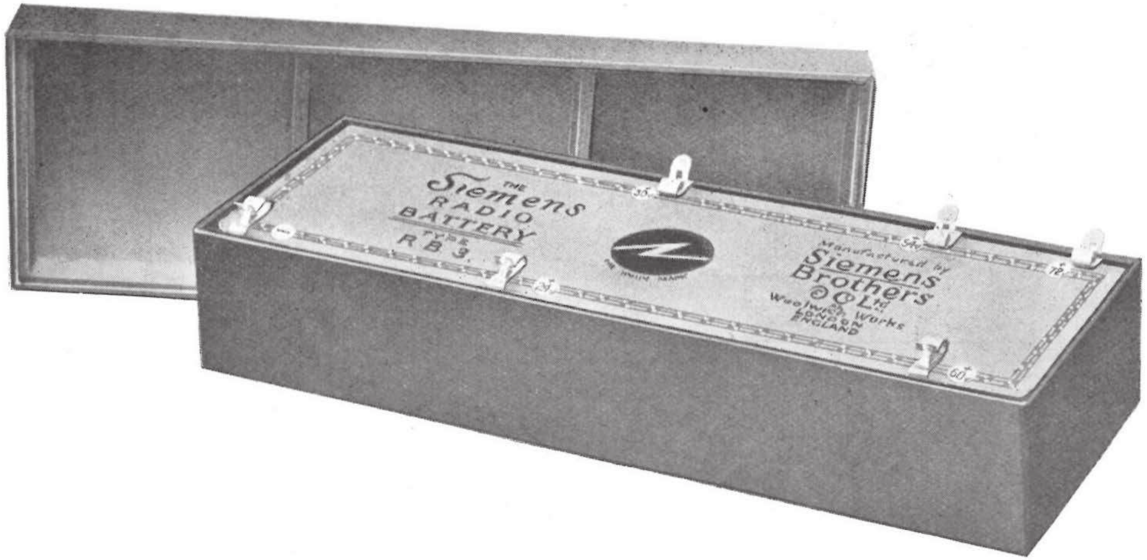

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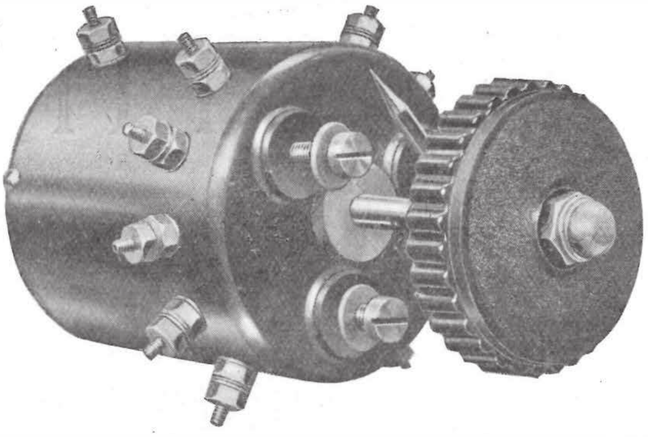

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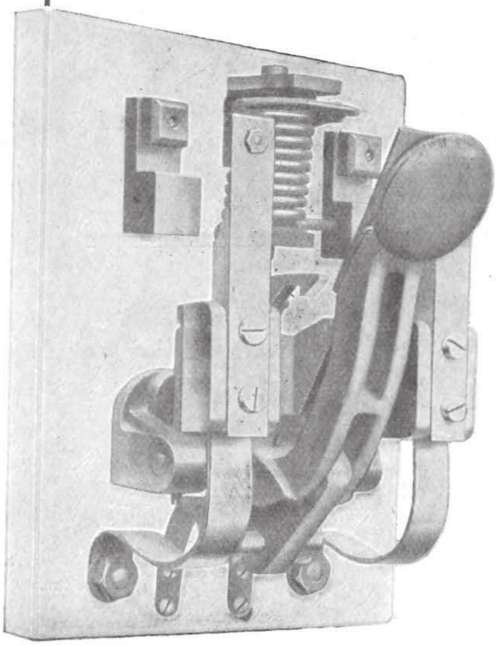

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A VOICE FREQUENCY TELEGRAPH SYSTEM.

By W. D. Hamilton.

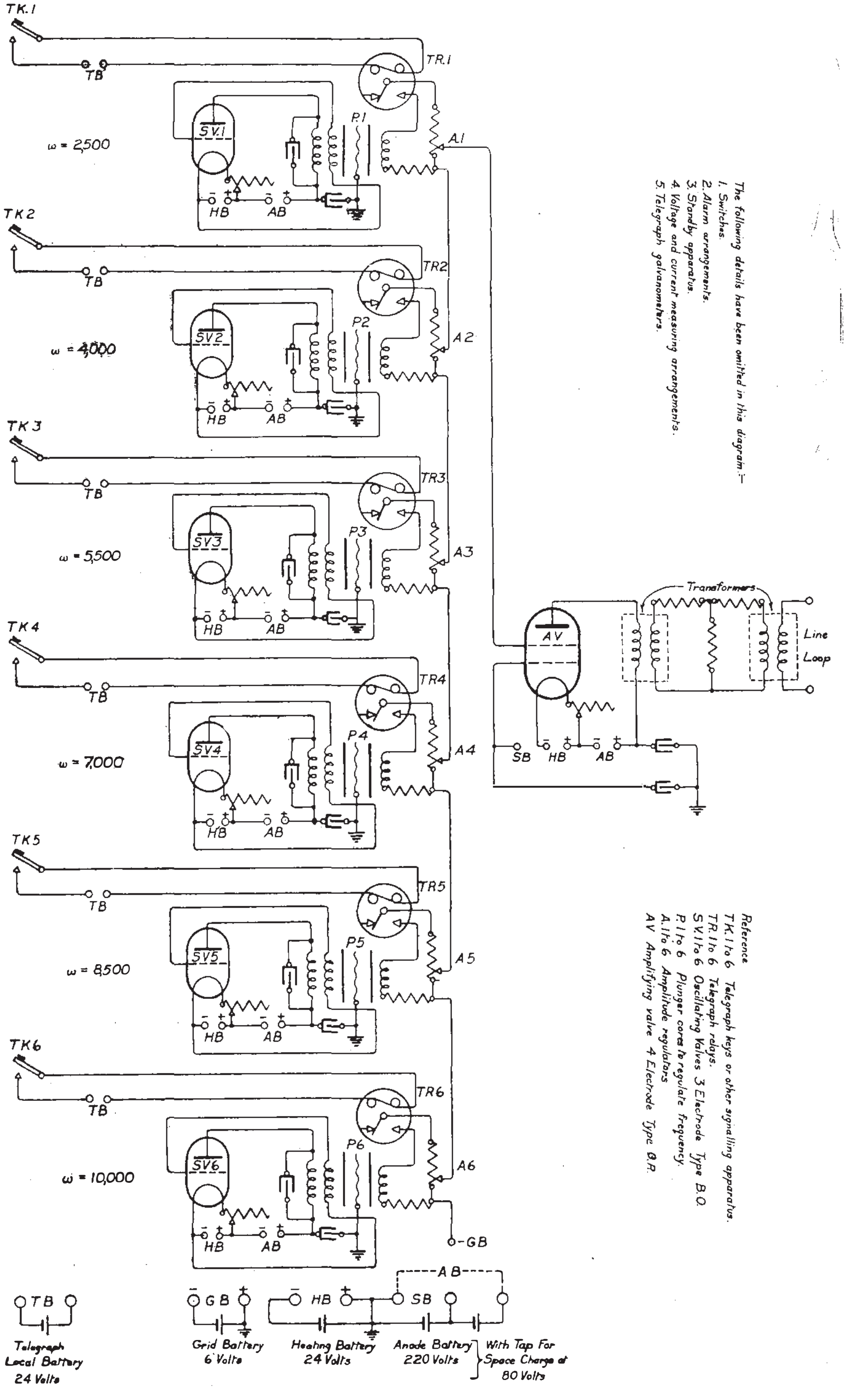
In view of the development of underground networks much attention has been given of late to systems of telegraphic transmission designed for use over small gauge conductors, loaded or unloaded, in lead-covered paper-core cable.

A satisfactory system of this sort would enable aerial trunk telegraph routes to be replaced by cable and secure for telegraphs the benefits of the greater stability of the cable circuits. The use of cable pairs as loop telegraph lines would also reduce immensely the liability to inductive disturbance from high-voltage and heavy-current circuits.

To be successful such a system must meet the following requirements:—

(1) Offer efficient transmission to existing types of telegraph, such as Morse, Wheatstone, Creed, Baudot, etc.
(2) Heavy current impulses, with steep rises and falls, should not be used on the cable loop line.
(3) It is desirable, if the cable is to be shared by telegraph and telephone circuits, that the telegraph signals over the cable should consist of alternating-current of the same order of amplitude and frequency as used in the telephonic pairs.
(4) If the telegraph pairs are loaded with the same loading as the telephone pairs, requirement (3) becomes essential to secure efficient transmission.

Many names have been used to designate systems devised on these lines, such as—High-frequency telegraphy, Tone (or Tonic) telegraphy, Speech-frequency telegraphy and Voice-frequency telegraphy. The first term is indefinite and, in view of the frequencies used in Wireless, it cannot be regarded as properly



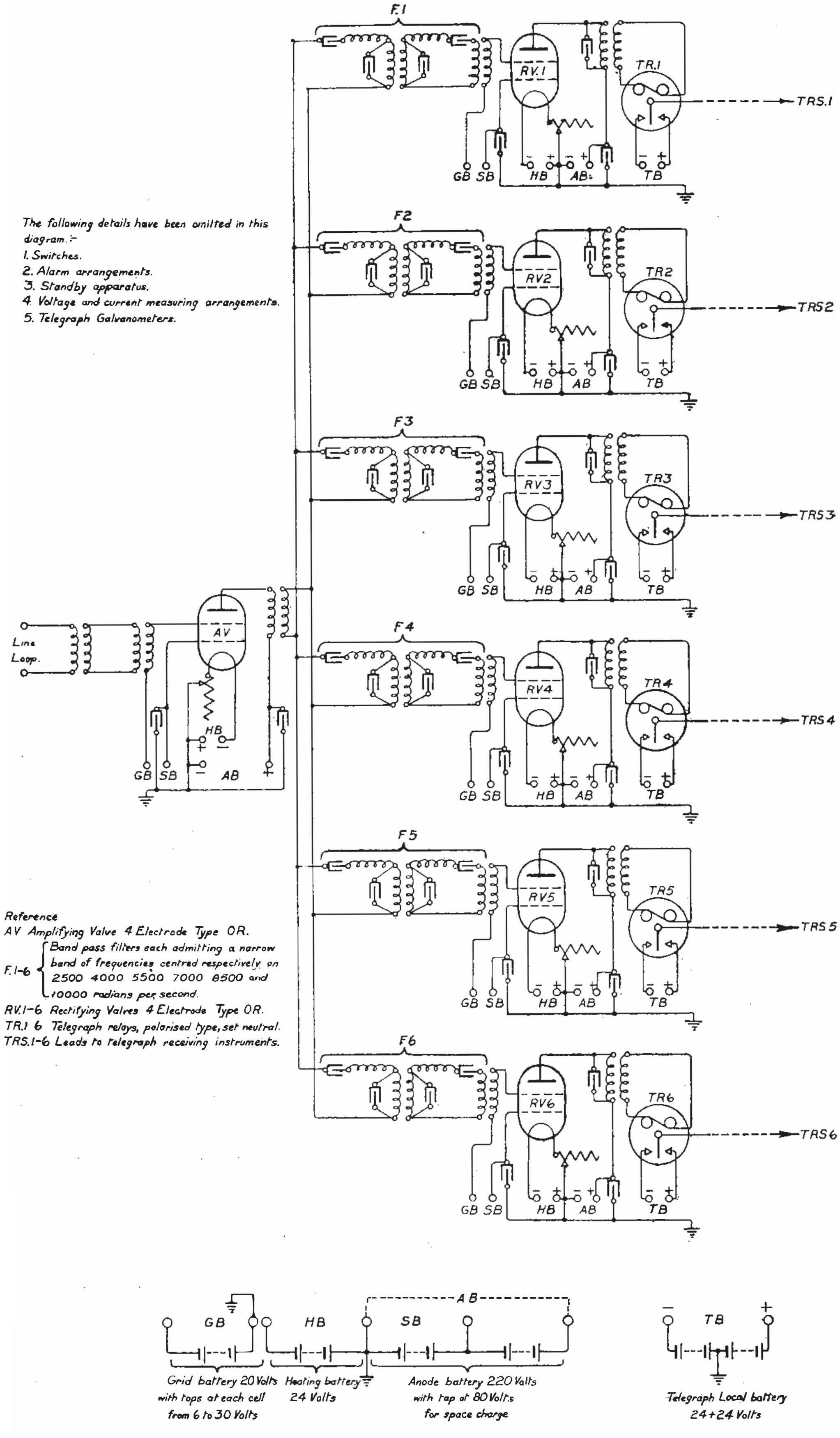
The following details have been omitted in this diagram:—

1. Switches.
2. Alarm arrangements.
3. Standby apparatus.
4. Voltage and current measuring arrangements.
5. Telegraph galvanometers.

Reference

TK.1 to 6	Telegraph keys or other signalling apparatus.
TR.1 to 6	Telegraph relays.
SV.1 to 6	Oscillating Valves 3 Electrode Type B.O.
P.1 to 6	Plunger cores to regulate frequency.
A.1 to 6	Amplitude regulators
AV	Amplifying valve 4 Electrode Type O.R.

Diagram Ex. 20340.— TRANSMITTING END.


F.1
F2
F3
F4
F5
F6
RV.1
RV2
RV3
RV4
RV5
RV6
TR.1
TR2
TR3
TR4
TR5
TR6
TRS.1
TRS2
TRS3
TRS4
TRS5
TRS6
Line
Loop.
AV
GB SB HB AB TB
HB
+ −
− AB +
A B
GB
HB
SB
TB
Grid battery 20 Volts with taps at each cell from 6 to 30 Volts
Heating battery 24 Volts
Anode battery 220 Volts with tap at 80 Volts for space charge
Telegraph Local battery 24+24 Volts

The following details have been omitted in this diagram.:–

1. *Switches.*
2. *Alarm arrangements.*
3. *Standby apparatus.*
4. *Voltage and current measuring arrangements.*
5. *Telegraph Galvanometers.*

Reference

AV Amplifying Valve 4 Electrode Type OR.

F.1–6 Band pass filters each admitting a narrow band of frequencies centred respectively on 2500 4000 5500 7000 8500 and 10000 radians per second.

RV.1–6 Rectifying Valves 4 Electrode Type OR.

TR.1 6 Telegraph relays, polarised type, set neutral.

TRS.1–6 Leads to telegraph receiving instruments.

Diagram Ex. 20341.– Receiving End.

applicable to the frequency-range used in transmitting speech by normal methods of telephony. The last-named—Voice Frequency—is favoured in this country and may be accepted as likely to become the standard term in the British Post Office.

Messrs. Siemens & Halske have developed a voice-frequency system on these lines. One sender rack and one receiver rack, which, together with the battery equipment, form a complete unit of the system were obtained early this year for trial in the Telegraph Section, Engineer-in-Chief's Office. Thermionic valves are utilised as generators, as amplifiers and as rectifiers. Three-electrode valves serve as oscillators (generators) and four-electrode valves, having a high amplification factor and a low internal impedance, are employed as amplifiers and as rectifiers.

Although a figure of approximately 800 cycles per second is regarded as the average of the alternating currents of telephony, it is well known that these currents vary over a considerable range on both sides of that average. The upper and lower limits in speech do not call for discussion here, but it will be agreed that frequencies from half (400) to twice (1600) the average cycles per second are well inside the voice-frequency range. Within this band Messrs. Siemens & Halske's system provides six separate channels on one pair of cable wires. As arranged, these channels only work one way and another pair of wires are needed to give six channels in the opposite direction.

A general idea of the operation of the system may be gained from a consideration of the diagrams on pages 214 and 215.

Transmitting End.—See diagram Ex. 20340. A key, transmitter or other telegraph sender, TK_1, in the telegraph instrument room is connected by a local line or loop to a polarised telegraph relay TR_1 on the transmitter rack of the voice-frequency installation. This rack may be located with the receiving rack in the Test room, the Exchange basement or other convenient position where the alarm system with which it is fitted can command skilled attention.

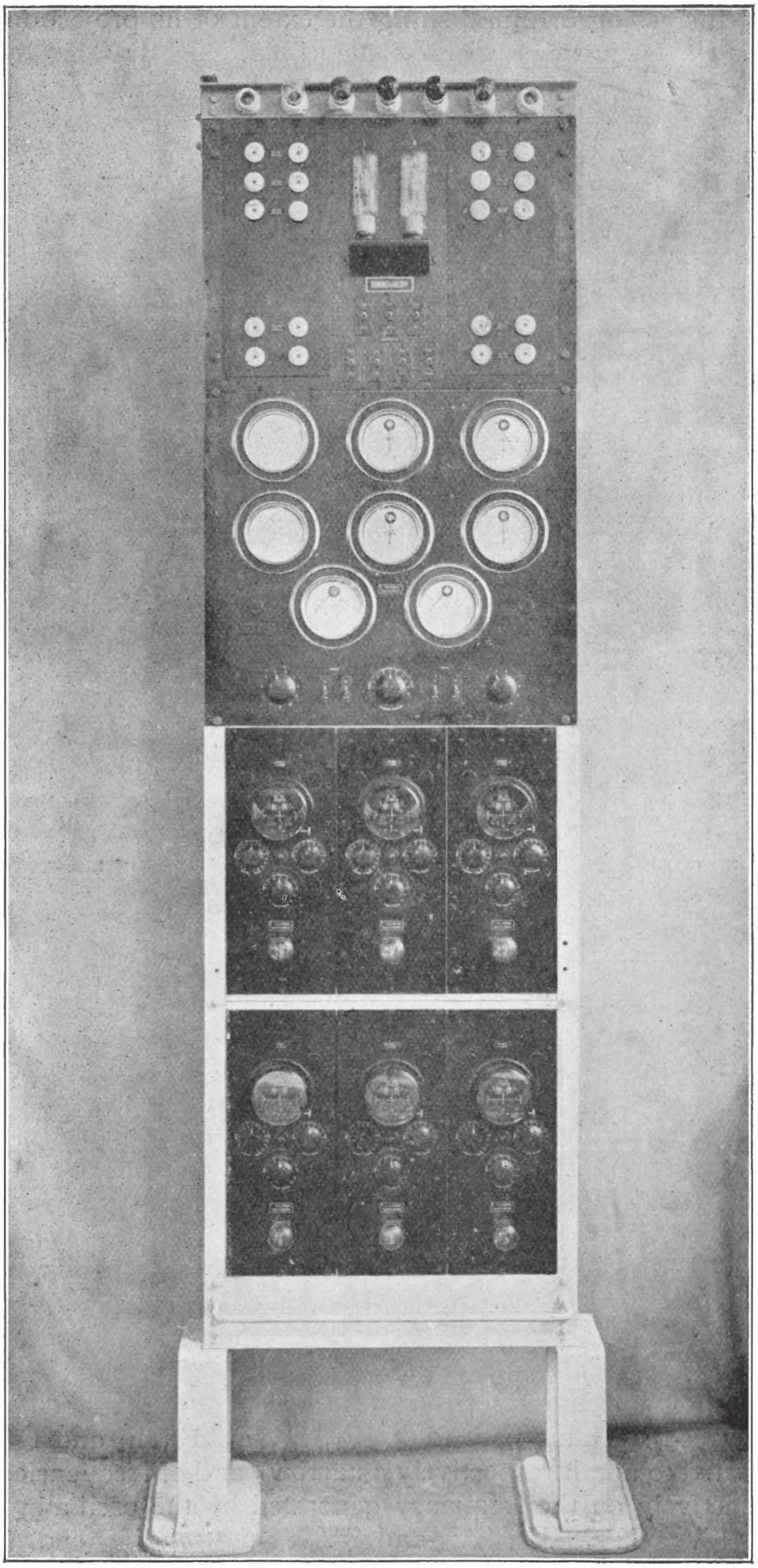
A 3-electrode valve, SV_1, mounted on the transmitter rack, has a reactance coupling between its plate and grid circuits. The constants of the coupled circuits are selected so that the valve, when the heating and plate batteries are switched on, oscillates continuously at a frequency of

$$f = \frac{2500}{2\pi} = 400 \text{ cycles per second (approx.).}$$

The elements of the reactance coupling are not variable, but it is necessary to allow for a slight divergence between the point of maximum admittance of the corresponding filter at the receiving end and the frequency generated. To effect this an adjustable iron plunger, P_1, projects into the hollow centre of the reactance coils. Its movement is controlled by a knob on the front of the rack, and by increasing or diminishing the extent of its projection into the coils the frequency generated may be slightly lowered or raised. The output coil of the oscillator completes its circuit *via* two resistances and the tongue and marking stop of the polarised telegraph relay TR_1. It follows that the output circuit is broken and takes no current unless the tongue of the relay is against the marking contact. One of the resistances A_1, termed the Amplitude resistance, forms part of the circuit between the grid battery and the grid of a 4-electrode amplifying valve AV. The amount of the amplitude resistance A_1 actually in the grid circuit may be adjusted by a sliding connection controlled by a knob on the front of the rack. By these means the frequency continuously generated by the oscillating valve SV_1 may be delivered to the grid of the amplifying valve AV in series of impulses corresponding to the " marks " from the telegraph key and the consequent closure of the tongue—marking stop circuit of the relay TR_1; the frequency generated may be varied with narrow limits and the amplitude of the alternating current input to AV may be controlled. In addition to the channel described there are five similar channels controlled by TK_2, TK_3, TK_4, TK_5 and TK_6 respectively. Each of these channels has, from telegraph relay to amplitude resistance inclusive, equipment on the transmitter rack similar to that on channel one. The constants of the reactance couples differ, however, and are of such value that valves SV_2, SV_3, SV_4, SV_5 and SV_6 give oscillations of 4,000, 5,500, 7,000, 8,500 and 10,000 radians per second respectively. The amplitude resistances A_2, A_3, A_4, A_5 and A_6 are in series with A_1 in the grid lead of the amplifying valve AV. Thus the depression of one or any combination of the telegraph keys closes the corresponding relays and results in a frequency, or an amalgamation of all or several of the frequencies being delivered to the grid of AV. On the release of any key the corresponding relay opens. The frequency or amalgamation of frequencies reaching AV is amplified and passes *via* an output transformer and a line transformer to the loop line and thence to the receiver rack of the distant Voice Frequency station, either direct, or, if necessary, through an intermediate valve repeater station.

Receiving End.—See diagram Ex. 20341. The frequency or amalgamation of frequencies arrives, attenuated, at the receiver rack, passing from the loop line *via* a line transformer and an input transformer, to an amplifying valve AV. The amplified output passes through an output transformer, across the secondary of which are teed six band-pass filters F_1, F_2, F_3, F_4, F_5 and F_6, each constructed to admit respectively a narrow band of frequencies centred respectively on the frequency generated by the oscillating valves SV_1, SV_2, SV_3, SV_4, SV_5 and SV_6 at the sending end.

Each filter terminates on the primary of an input transformer.



Alarm Lamps.

A.V. and Stand-by.

Anode Voltage keys.

Telegraph Galvos.

Voltmeter and Ammeter.

Filament Res. and Key controls.

Telegraph Relays.

Valve controls.

Oscillating Valve.

See above.

FIG. 1.—FRONT OF TRANSMITTER FRAME.

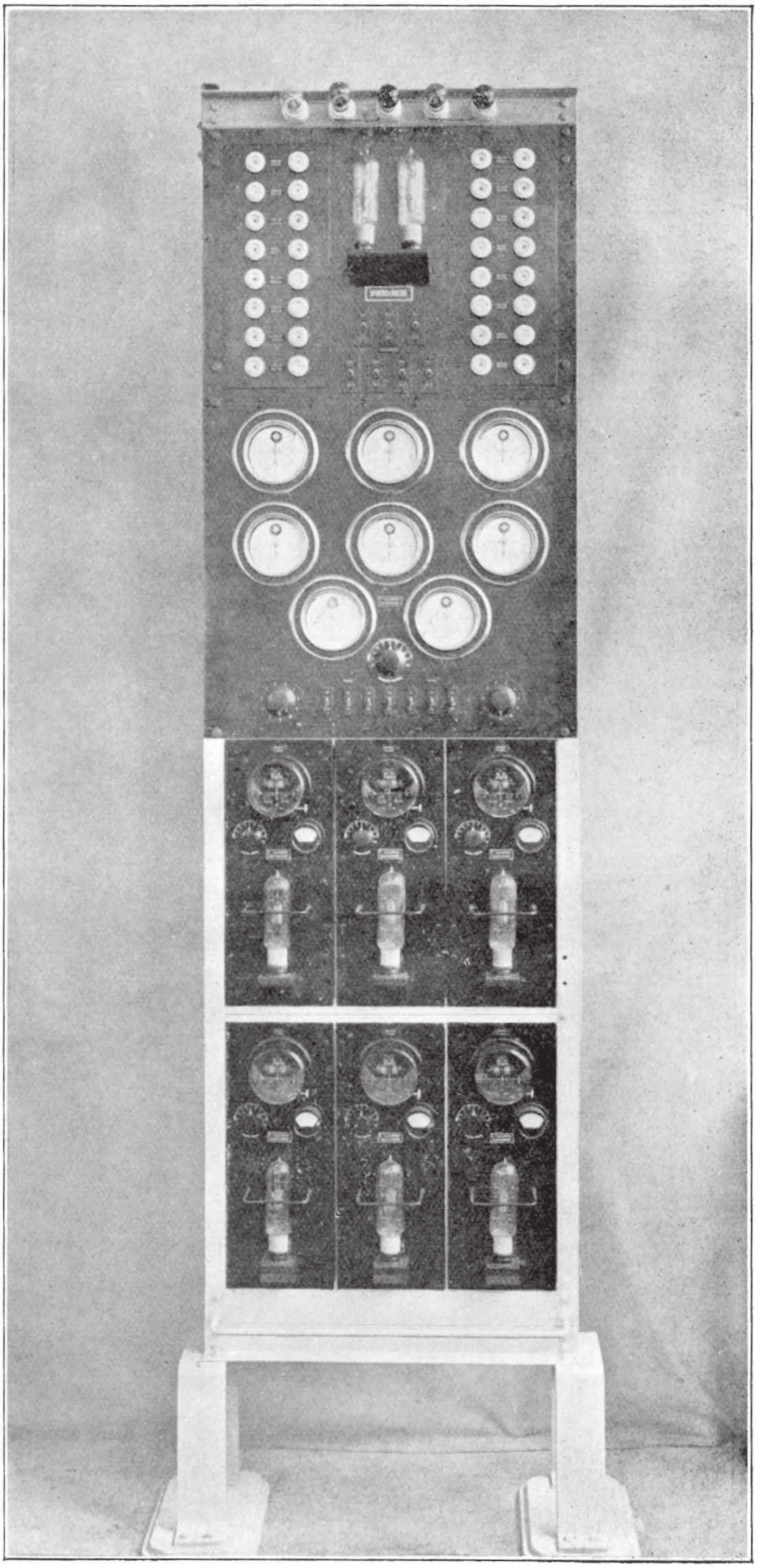


FIG. 2.—FRONT OF RECEIVING FRAME.

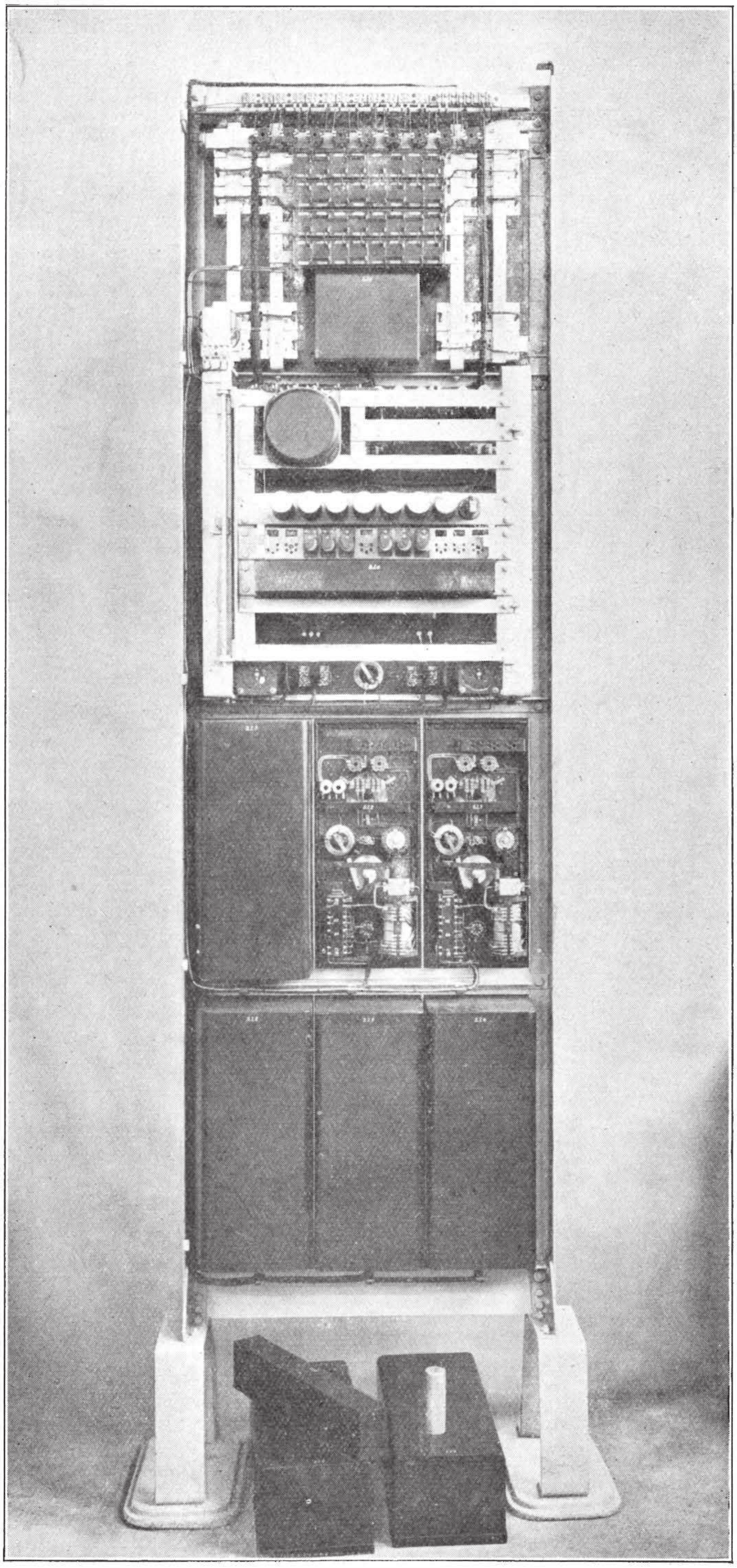


FIG. 3.—BACK OF TRANSMITTER FRAME.

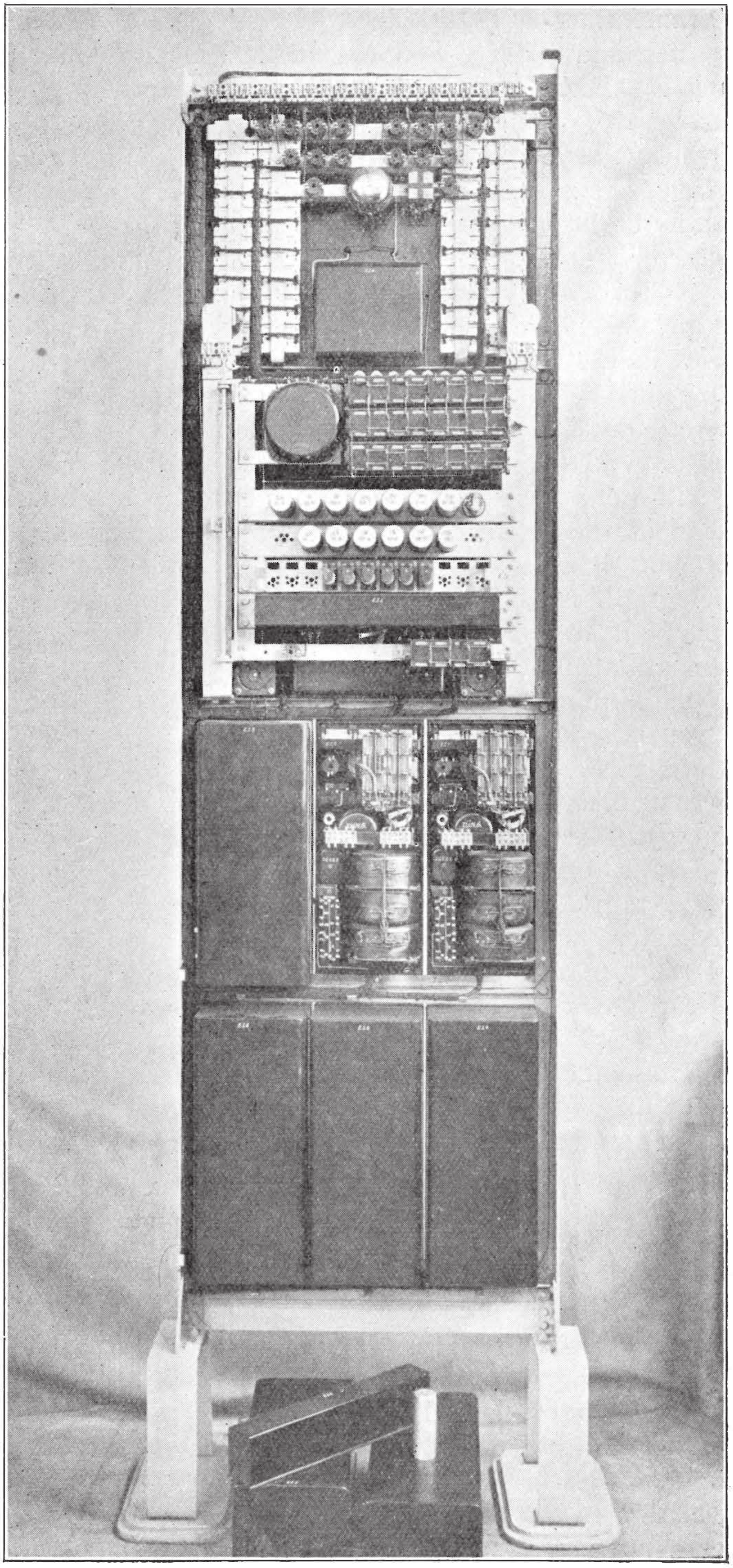


FIG. 4.—BACK OF RECEIVER FRAME.

Each transformer is thus open to receive one of the six filtered frequencies and pass it to the grid of the particular rectifying valve RV_1, RV_2, RV_3, RV_4, RV_5 or RV_6 connected to the secondary.

By means of a grid battery the grids of these rectifying valves are primed negatively to a point on the Characteristic Curve, where any additional voltage reaching the grid will be amplified, if positive, but suppressed, if negative. By this means the "gushes" of A.C., corresponding to the depression of, say, TK_1, which have been admitted by F_1 are rectified to undulatory current impulses in the output circuit of RV_1. The output transformer has its primary coil shunted by a condenser, the effect of which is to smooth out the undulations of current in the primary coil, leaving only a D.C. element to affect the secondary. Consequently there will be a single short impulse in the secondary at the initiation of the rectified current impulse in the primary and a single short impulse in the reverse direction at its termination. The telegraph receiving relay TR_1 is in series circuit with the secondary; its armature is set neutral and the relay is so connected that the initial impulse carries its tongue to the marking contact, while the terminal (reverse) impulse restores the tongue to the spacing side. The tongue of the relay is joined, by means of a local line, to the appropriate telegraph receiving apparatus TRS in the instrument room. The working of the other five channels is similar to that of the one described.

The appearance of the voice-frequency apparatus may be seen from the reproduced photographs. The top of the frames is approximately 9 feet 6 inches from the ground. Referring to Fig. **1** the top sections contains (1) a horizontal row of coloured lamps for alarm indicators; (2) 2 valves—the AV valve and its stand-by; (3) immediately below the valves 7 switches for connecting the anode voltage to each valve; (4) four vertical rows—two on right and two on left—of fuse mountings.

The second section of the frame carries six telegraph galvanometers, one ammeter and its rotary switch, one voltmeter and its rotary switch, a rotary switch (middle) for adjusting the filament current of the amplifying valve AV, and four keys for connecting up the heating circuits. The third and fourth sections each consist of three units of the oscillators. Each unit consists of (1) telegraph relay; (2) a rotary switch for regulation of the amplitude of the output; (3) a rotary switch for regulating the heating current of the adjacent valve; (4) a rotary handle for adjusting the frequency generated; (5) a three-electrode valve connected as an oscillator.

Referring to Fig. **2**, the two top panels are similar to those of Fig. **1** save that there are more fuses and heating circuit switches. This is due to all valves on this frame being heated independently, whereas the oscillator valves are heated with pairs in series. The third and fourth panels consist of the six rectifying units. The apparatus on each is (1) telegraph relay; (2) a rotary switch for heating current regulation; (3) a milliammeter for measuring the output of the rectifying valve adjacent; (4) a 4-electrode valve functioning as a rectifier. Back view of the frames are shown on Figs. **3** and **4**, and views of a single oscillator unit and a single rectifier unit on Figs. **5** and **6**.

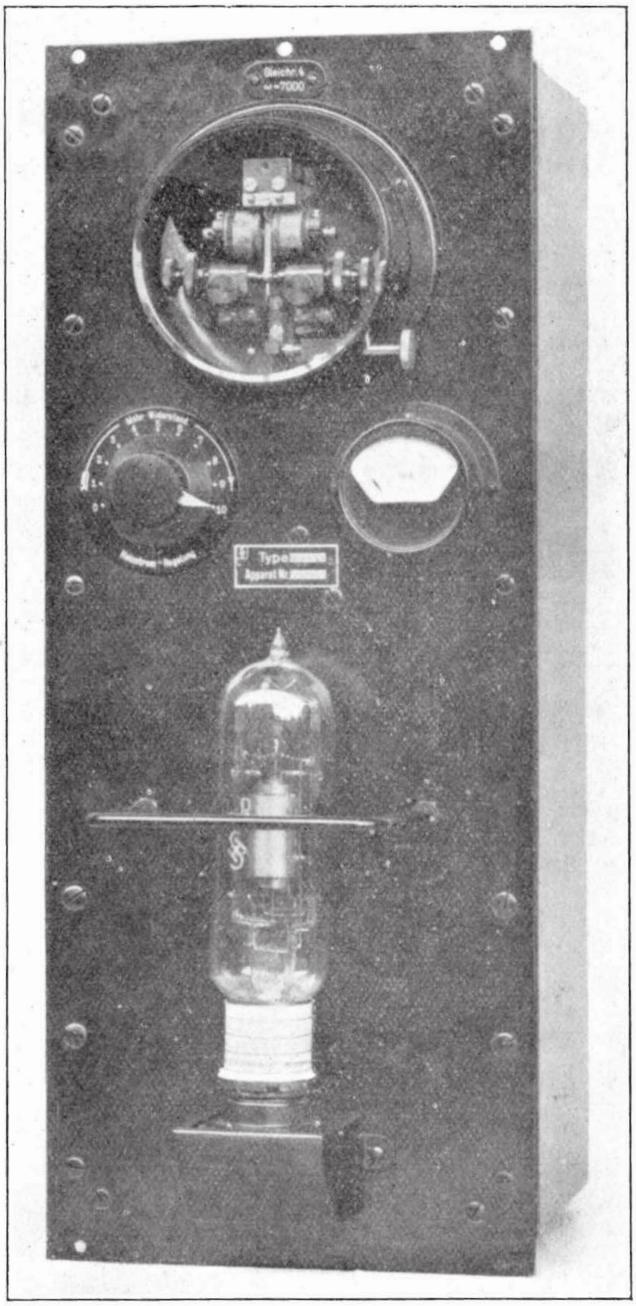


FIG. **5**.—ONE UNIT FRAME OSCILLATING RACK OF TRANSMITTER FRAME.

Wheatstone speeds of 100 words per minute have been attained on all six channels simultaneously over an artificial line equivalent to 24 s.m. of loaded cable. Using a repeater unit in the centre of the line similar results were obtained over 48 s.m. Unfortunately building operations in T.S. made it necessary to vacate the Experimenting Room when the experiments were on the point of being carried to real lines. A new room is being provided and fitted and it is hoped to resume trials shortly.

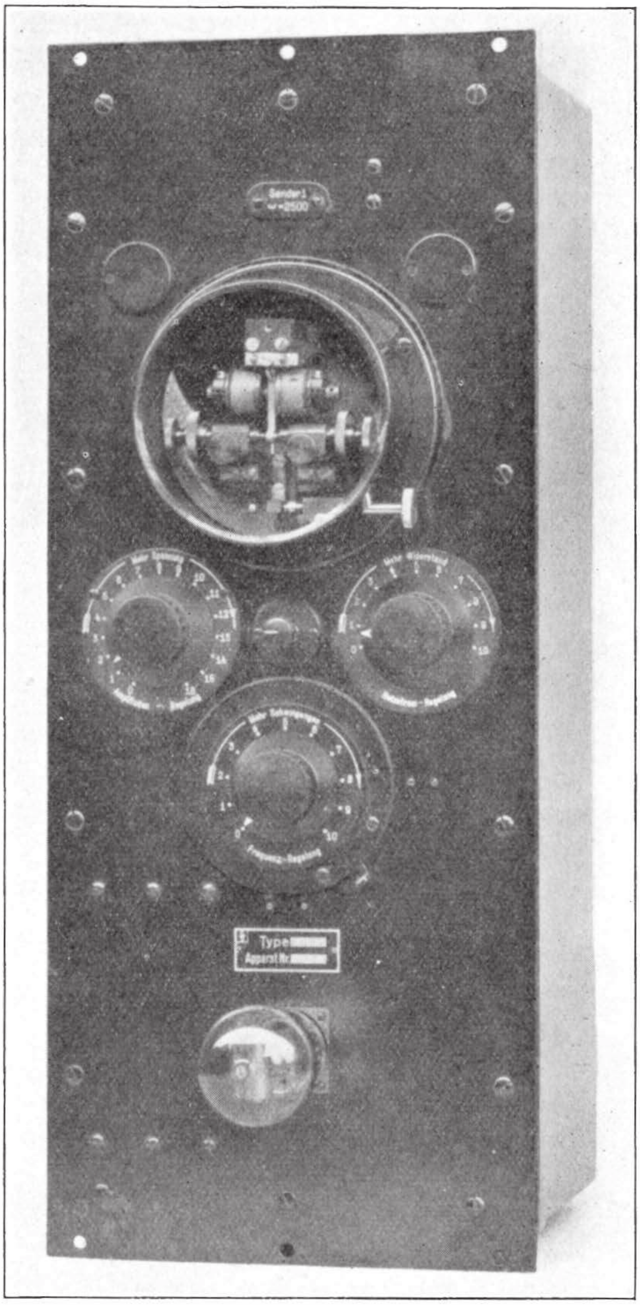


FIG. 6.—ONE UNIT FRAME RECTIFIER RACK OF RECEIVING FRAME.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT 30TH JUNE, 1925.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
454,727	617	4,186	55,954	461	London	22,547	50,112	1,553,613	46,882
54,392	1,897	19,414	54,858	1,714	S. East	3,825	20,069	87,735	14,764
57,381	4,386	25,536	43,612	1,671	S. West	13,314	4,460	85,403	26,499
45,076	8,390	30,618	39,994	5,527	Eastern	13,950	22,630	47,101	46,431
76,918	8,590	41,299	50,785	3,258	N. Mid.	19,034	31,580	134,309	78,995
54,471	4,802	25,790	54,959	4,416	S. Mid.	11,892	13,861	105,844	81,649
50,331	5,099	28,255	44,346	1,887	S. Wales	5,237	15,120	81,600	54,441
80,886	8,464	23,379	41,670	5,240	N. Wales	12,206	29,641	146,233	46,880
126,280	2,953	16,598	46,658	3,453	S. Lancs.	12,392	58,730	327,554	35,599
75,811	6,411	29,706	42,042	2,501	N. East	8,074	29,450	165,500	24,812
50,789	3,828	23,788	37,451	2,203	N. West	8,561	28,853	95,390	6. 25,935
39,192	2,547	15,334	23,565	2,076	North	2,792	8,392	63,307	25,168
17,900	4,781	5,942	11,502	241	Ireland N.	139	84	28,750	73
52,232	5,575	21,050	31,722	1,231	Scot. East	1,629	6,380	95,933	11,356
74,828	7,467	22,634	39,252	903	Scot. West	12,627	22,445	185,176	23,873
1,311,214	75,807	333,529	618,370	36,782	Totals.	148,219	341,807	3,203,448	543,363
1,280,725	75,841	331,447	612,204	36,711	Figures on 31st Mar. 1925.	143,783	326,725	3,101,556	523,527

JUNCTION WORKING BETWEEN AUTOMATIC AND MANUAL EXCHANGES. NON-DIRECTOR AREAS.

By I. H. Jenkins, A.M.I.E.E., and J. S. Paterson,
E.-in-C. Office.

This article describes the method of interconnecting automatic and manual exchanges in non-director areas. The method of working Director areas (*i.e.*, large areas like London) was dealt with in the articles on the " P.O. Exhibit at the British Empire Exhibition," by Messrs. W. E. Hudson and F. I. Ray, in the July and October issues of this Journal last year.

The principles employed in automatic systems for signal control differ fundamentally from anything existing in manual exchanges. This has given rise to circuit problems of considerable difficulty and the following is an attempt to indicate how these have been solved :—

A subscriber connected to an automatic equipment is provided with means, under the control of his dial, of setting up a connection within the local fee area. During the transition period, however, some of the exchanges within the local fee area will be of the manual type and the subscriber's dialling puts him into communication with the manual exchange operator, who completes the connection ; these calls are known as dialled-out calls. Calls originated by automatic subscribers for exchanges outside their local fee area are handled on the automatic exchange manual positions and obtained by the subscriber dialling " 0." This is a permanent feature of an automatic system and is necessary for accounting reasons, the subscriber's meter being designed to record one local call fee unit only for each call.

Conversely, calls originated by subscribers on manual exchanges are set up by the manual operator, who is provided with a dial, or its equivalent, for obtaining the automatic subscriber direct through the automatic switches; these calls are known as dialled-in calls. Within this category are included calls from manual exchanges or from manual positions at automatic exchanges inside and outside the local fee area. The provision of dialling-in junctions is determined only by traffic requirements and engineering considerations governed usually by the length of line.

The principle of standard junction signalling between manual exchanges provides that a current is sent on the " B " wire from the outgoing end to an earthed calling relay at the incoming end and that the supervising signal is given by current sent on the " A " wire from the incoming end to an earthed supervisory relay at the outgoing end.

In the case of outgoing junctions to Automatic, signalling can be either direct to a selector line relay or *via* an incoming repeater at the automatic exchange. Where repeaters are used, the signalling is the same as in manual to manual junctions and this will be dealt with later. Where the junction is connected to a selector direct, the line relay associated with the selector is double-wound, one coil being connected to a battery and the other to earth. It will be seen therefore that a loop made at the manual exchange will operate the selector line relay and if this loop is made through a dial, impulses can be transmitted to the auto system.

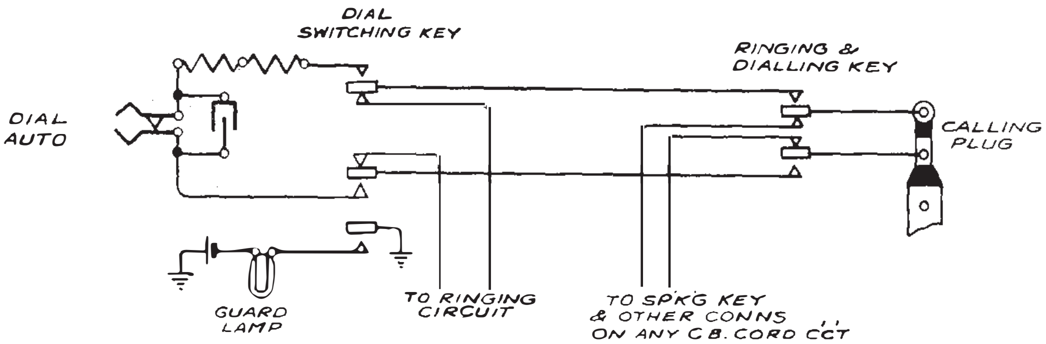


FIG. 1.

" LOOP " DIALLING-IN FROM C.B. EXCHANGES.

Where line limits permit, the adopted practice is to terminate the junction direct on a selector and provide the operators with the means of dialling from any cord circuit, one dial being common to a position. The standard method is to connect the dial through a switching key to the commons of the ringing keys of the cord circuits, so that the position of the switching key determines whether the calling plugs will be connected to the ringing or to the dialling circuit (see Fig. 1).

Where most of the connections made by the operators will require ringing a guard lamp is necessary to indicate when the dial switching key is left in the position for dialling.

The most important precaution to be made is to suppress false impulses.

If a selector be connected direct to an outgoing junction jack, it will be seen from Fig. **2** that during the process of inserting the plug in the jack, the tip of the plug, to which is connected an earthed supervisory relay, will invariably touch the " B " spring of the jack and energise the selector line relay momentarily, thus producing a false impulse.

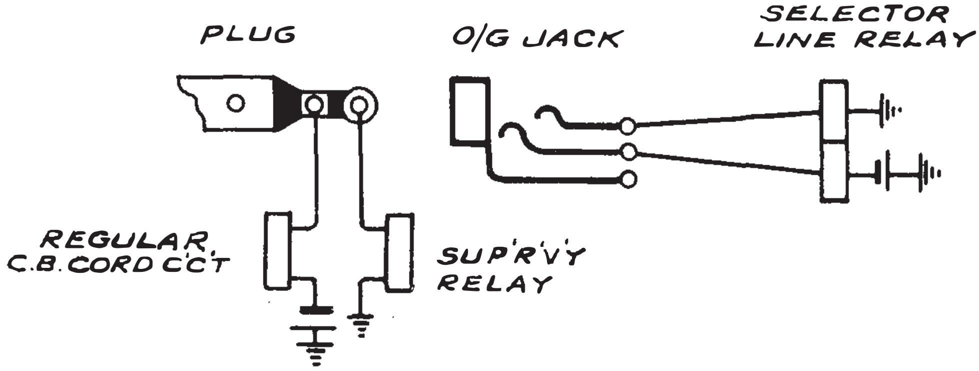


FIG. **2**.

To avoid this defect it is necessary to keep the selector line relay off the outgoing jack until the plug is fully home in the jack. This equipment is shown in Fig. **3**. It is so arranged that the line is not connected until the plug is home and the dial connected to the plug. The operation is as follows :—

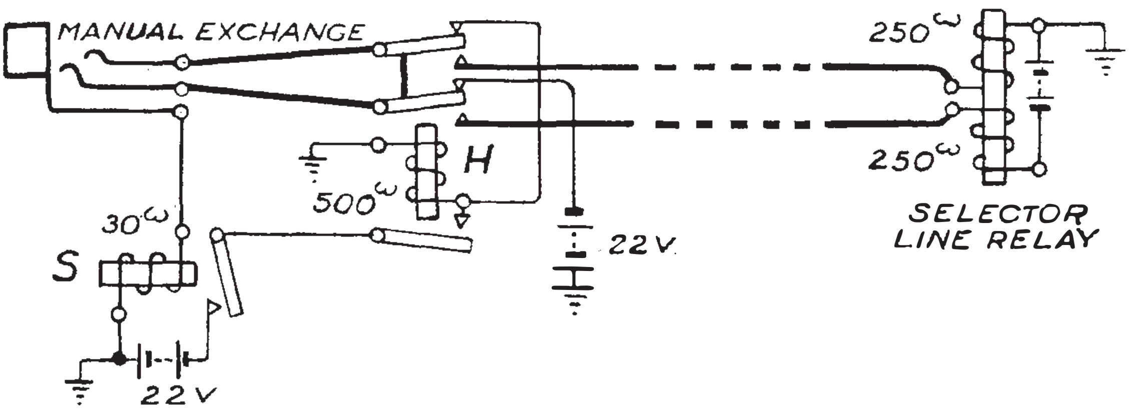


FIG. **3**.—FALSE IMPULSE SUPPRESSING DEVICE.

The operator inserts plug in jack and relay S is actuated by current from sleeve of plug. The operation of S prepares a holding circuit for relay H.. The dial switching key is thrown, which connects the dial circuit to the commons on the outer spring of " ringing and dialling " key. The latter is then held over and the loop from the dial circuit operates relay H, which connects up the line and holds in *via* contact of relay S. The operator dials the required number and then releases the " ringing and dialling " key.

At this stage the junction is through to the wanted subscriber, but it is necessary that the circuit should be held by the cord circuit until and after the called subscriber answers.

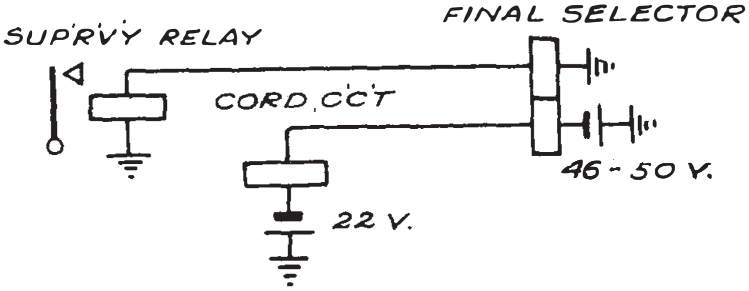


FIG. 4.

A reference to Fig. 4 will show that the auto exchange equipment is held only on one coil of the relay and that there is battery connected to each end of that one coil. The holding current is therefore determined by the *difference in voltage between the batteries* at each of the two exchanges concerned. Fig. 5 shows that a reversal takes place when called party answers. The batteries at both exchanges are now assisting each other and the supervisory relay in cord circuit is actuated by current from auto exchange. It is the condition shown in Fig. 4, however, that limits the resistance of the junctions for " loop " dialling.

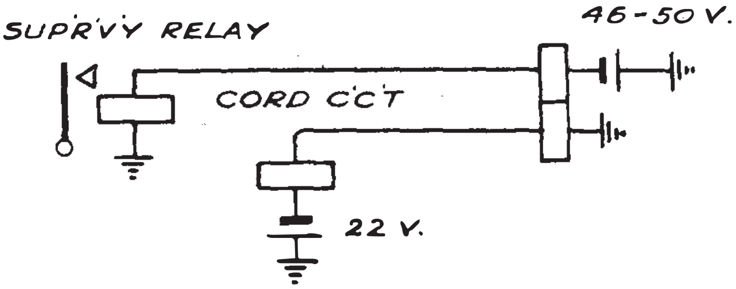


FIG. 5.

At 40-volt exchanges dialling-in direct to a selector line relay is impracticable, because the voltages at each end are too nearly equal to permit of holding the switches prior to and after dialling. For a similar reason, single-battery 22-volt exchanges are limited to 100 ohms loop, because in these exchanges the voltage may rise to 28 or 30 during charging.

22-Volt and 24-volt exchanges with two sets of cells can dial in direct to selector, subject to the limits shown below, but where

30-volt transmission circuits are installed, *e.g.*, Jack-ended Junction cord circuits, " Loop " dialling will be restricted to the lowest holding limit quoted below, *i.e.*, 100 ohm loop.

Line limits for " Loop " dialling.

22-volt exchanges,	double battery.	350 ohm loop res.
24-volt ,,	,, ,,	280 ,, ,, ,,
22-24-volt ,,	single ,,	100 ,, ,, ,,
,, ,,	with 30-v. jct. cord circuits.	100 ohm loop res.

BATTERY DIALLING FROM C.B. EXCHANGES.

Battery dialling is necessary at all C.B. exchanges where the cord circuit voltage exceeds 30 and at other exchanges where the line resistance of the junctions exceeds the limits for holding given under the heading of " Loop " dialling.

" Battery " dialling is effected by inserting a repeater circuit at the automatic end between the junction line and the selector.

The repeater provides for regular junction signalling as in the manual to manual practice already referred to.

In addition, it has to repeat the dial impulses and hold the selector, as in the case of " Loop " dialling.

Fig. **6** shows the conditions on the junction side of the repeater.

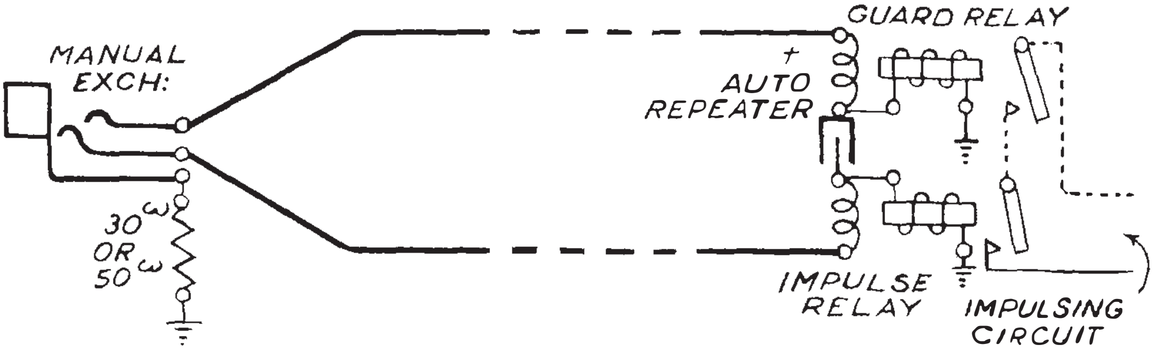


FIG. **6**.—OUTGOING JUNCTION WORKING TO REPEATER.

Unlike the " Loop " dialling junctions, there is no false impulse-suppressing equipment required at the outgoing end, for the reason that the impulsing circuit is not connected until the plug is fully inserted and the dial and ringing key thrown. The circuit conditions just after the plug has been inserted in the outgoing jack are shown in Fig. **7**.

The guard relay is not operated and the impulsing relay is operated, but the impulsing circuit is not connected until the guard relay is operated.

Fig. **8** shows the conditions when the dial circuit is joined up by the operation of the keys as described for " loop " dialling.

The operation of the dial circuit keys connects battery in parallel over the A and B wires and both "guard" and "impulsing" relays are operated. The latter responds to the impulses from the dial, but the former is kept steadily operated. Figs. **6**, **7** and **8** are only schematic and do not show the actual connections at the auto repeater.

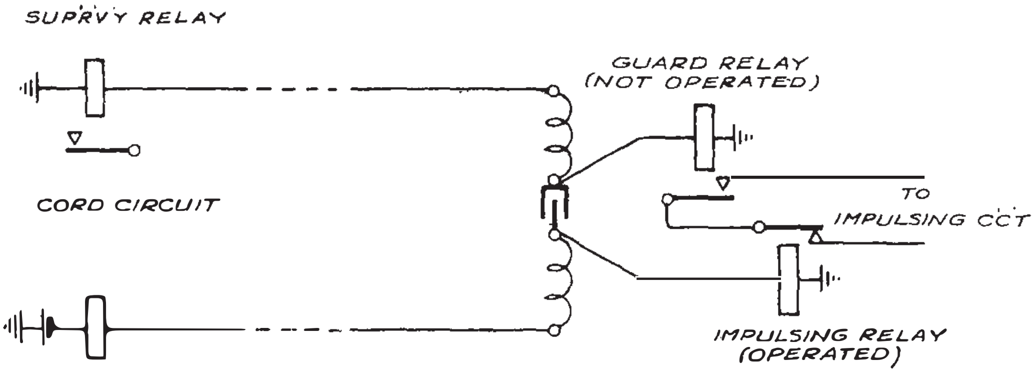


FIG. 7.

Fig. **9** shows a repeater in detail.

The insertion of a plug in the outgoing jack actuates relay "A." This performs no function with regard to the call meantime, but is used to make the outgoing portion busy (at auto end) in the case of a bothway line. The operation of the dial circuit keys (see Fig. **8**) actuates relay "L" (relay "A" remains operated), then relay G and GB operate in turn. G cuts off the

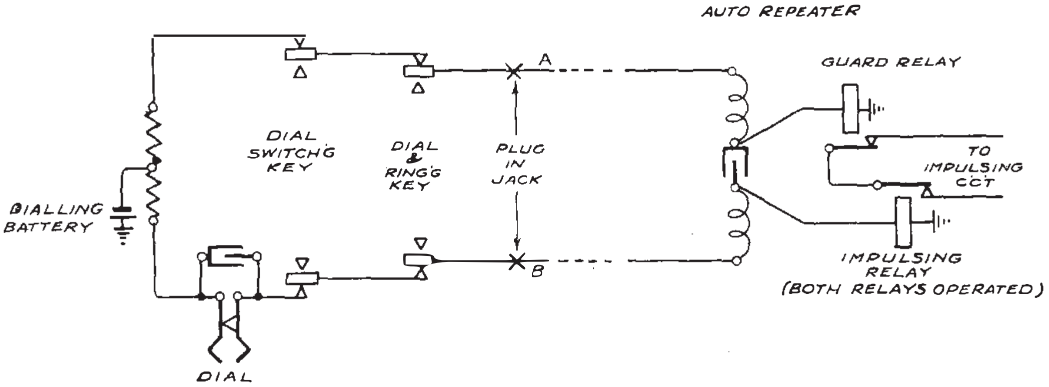


FIG. 8.—"BATTERY" DIALLING CIRCUIT CONDITIONS.

repeating coil and therefore relays D and DD. It also removes the earth connection from impulsing circuit and provides a loop of 250 ohms across the selector relay (not shown) *via* contacts of relay A. Dialling is commenced and impulses sent to selector. When dialling key is restored, L and G release, but GG being slow is held in by the earth on A contact, which has been restored by the release of G. The selector is now straight through to the repeating coil.

The 0.5 m.f. condenser placed in shunt with D by DD is to improve the volume of tone when " Busy Back " is received on an engaged line, the impedance of D being too great to allow of satisfactory busy tone being transmitted to the calling party. If circuit be disengaged, relay DD is released and D actuated when the calling party replies. D substitutes battery for earth through

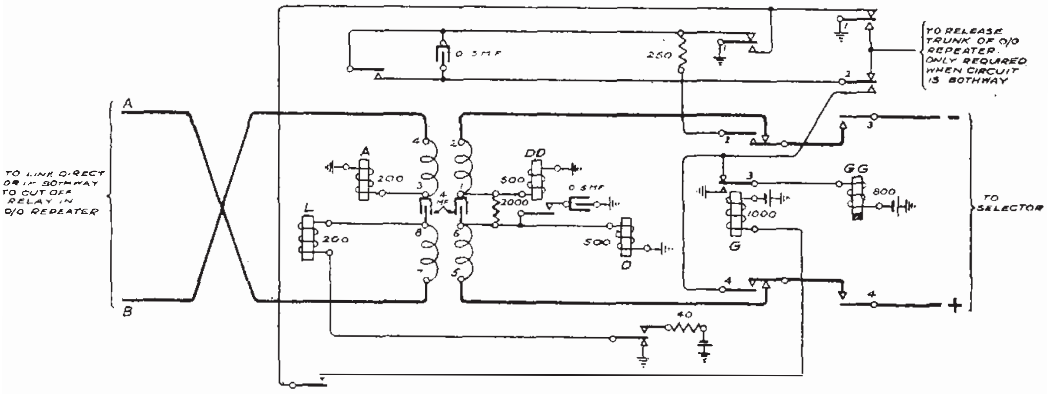

TO RELEASE TRUNK OF O/G REPEATER. ONLY REQUIRED WHEN CIRCUIT IS BOTHWAY
0 5 MF
250
A
B
TO LINK DIRECT OR IF BOTHWAY TO CUT OFF RELAY IN O/G REPEATER
A
200
L
200
4 MF
DD
500
2000
0 5 MF
500
D
GG
800
1000
G
40
TO SELECTOR
-
+

FIG. 9.—INCOMING REPEATER AT AUTO EXCHANGE (WITH REPEATING COIL).

L and sends the supervisory current, out on the A line, to the calling exchange.

The repeater just described is suitable for lines subject to noisy conditions.

(1) Fig. **10** shows a circuit which has been designed to reduce the transmission losses by the omission of a repeating coil in the transmission circuit.

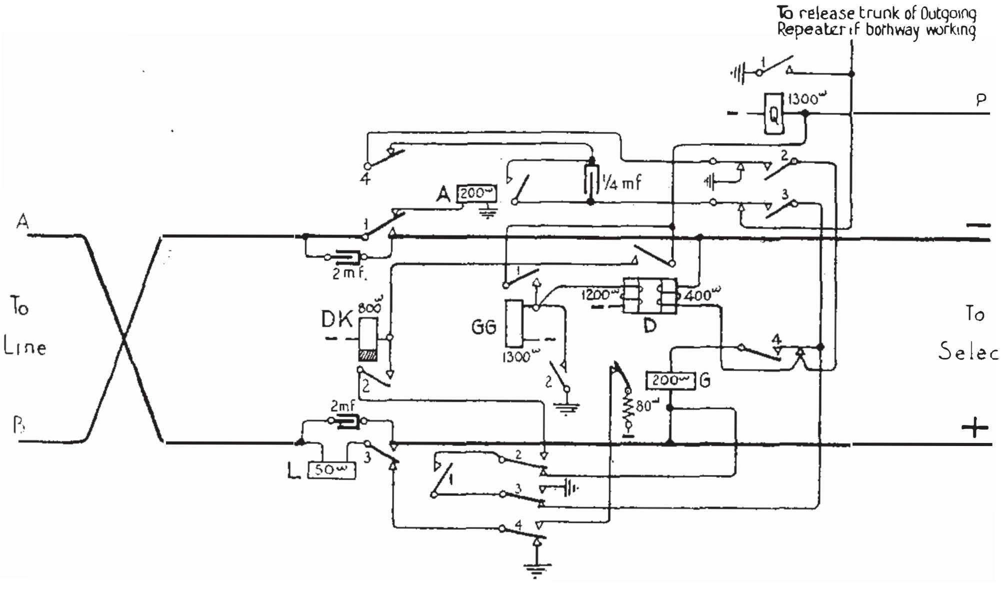


FIG. 10.—INCOMING REPEATER AT AUTO EXCHANGE (WITHOUT REPEATING COIL).

(2) Provison is made for :—

(*a*) Engaging on the insertion of the plug at the manual end the outgoing multiple bank in the case of bothway working.
(*b*) Seizing the selector on throwing the dialling key.
(*c*) Conversion of battery dialling impulses to loop impulses.
(*d*) Transmitting the busy back flash.
(*e*) Transmitting through signalling from the called subscriber.
(*f*) Vesting the control of the switches in the originating manual operator.

Operation.

(3) *Relay A* operates on the insertion of the plug. Its functions are: first, to engage the outgoing multiple bank and, second, to act as an impulsing relay after the operation of Q, and on release to disconnect the loop.

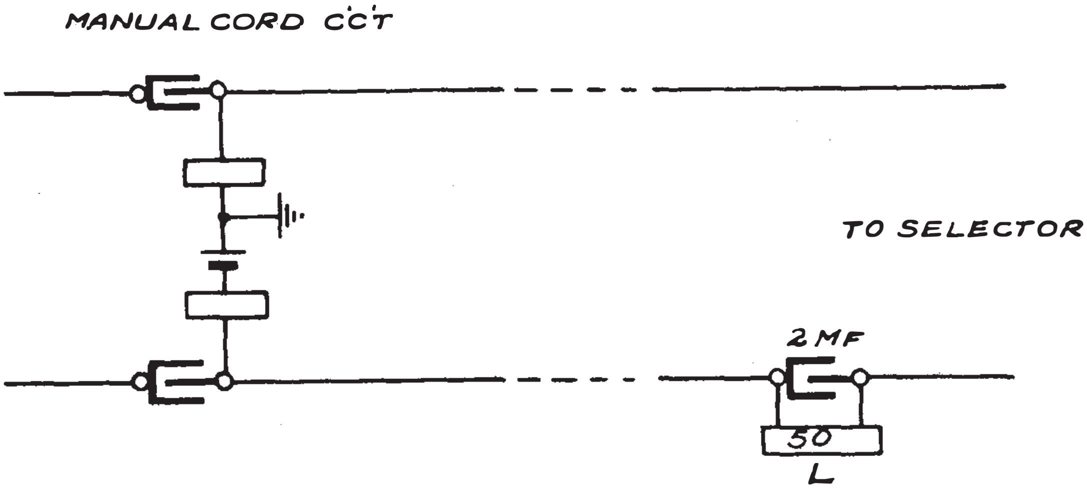


Fig. **11**.

(4) *Relay L* operates on the throw of the dialling key. Its functions are: first, to complete the loop and seize the switch and, second, to short-circuit Relay G and, third, to provide a holding circuit for relay DK. Relay G is short-circuited whilst the dialling key is thrown to maintain the control of the switches by the calling operator in the event of the called subscriber replying before the dialling key is released.

(5) *Relay Q* operates on the seizure of the switch. Its functions: are (1) to maintain earth on the outgoing multiple bank, (2), (3) and (4) to transfer spring of Relay A to the loop for impulsing.

(6) *Relay G* operates on the release of the dialling key. Its functions are: (2) to energise Relay GG, (1) to connect battery to the A line to flash the cord circuit supervisory lamp when busy back has been dialled into.

(7) *Relay GG* operates when G operates. Its functions are: (1) to lock through earth on the private, (2) and (3) to transfer the spring of Relay L to DK for holding, (4) to connect A line to G for busy back flashing.

(8) *Relay D* operates when the called subscriber answers and energises Relay DK.

(9) *Relay DK*. DK is operated by D. Its functions are: (1) to disconnect Relay A and connect the B line through to negative, (3) to connect the A line to positive through Relay L, (2) to provide a holding circuit for itself, (4) to sever the signalling bridge.

The circuit conditions during conversation are as shown in Fig. **11**.

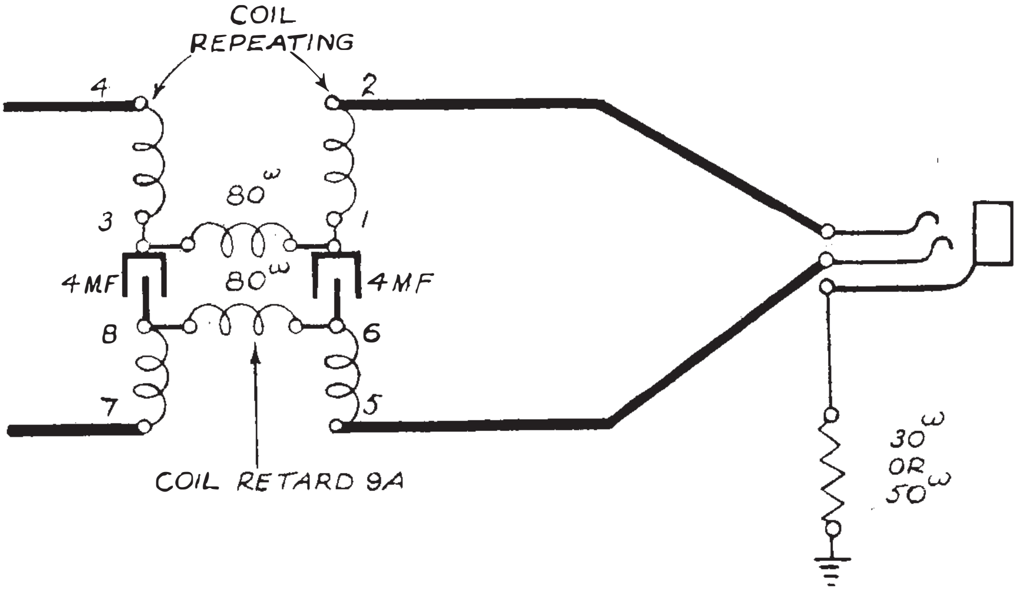


FIG. **12**.—NOISE ELIMINATING EQUIPMENT.

" BATTERY " DIALLING THROUGH NOISE ELIMINATING EQUIPMENT.

Figs. **12** and **13** show the auxiliary equipment required for " noisy " lines over which dialling is required.

" Battery " dialling only is provided for, because, owing to the low line limits for " loop " dialling from C.B. exchanges, it is not anticipated that such short lines will require noise eliminating equipment, but Fig. **12** could be used for loop dialling with the addition of a false impulse-suppressing relay equipment as in Fig. **3**.

In Fig. **12** the 80 + 80 ohms retardation coil provides a physical path for holding and impulsing through the repeater at the auto exchange.

Fig. **13** is an adaptation of what was the standard noise eliminating equipment with an additional relay and connections for dialling through. The insertion of the plug in the jack operates relay C by the current from the "ring" of the cord circuit, the repeater at auto exchange is then seized. The operation of the dialling keys, as already described, actuates relay D, which releases relay C and connects the line through direct to the exchange side of the repeating coil. Impulses are transmitted from the dial over the B line, whilst battery is kept steadily applied to the A line to operate the "guard" relay.

The restoration of dial keys re-operates relay "C," and the relay S responds to the supervisory current on A line when the called subscriber answers, closing terminals 1 and 6 of repeating coil through the 200-ohm spool.

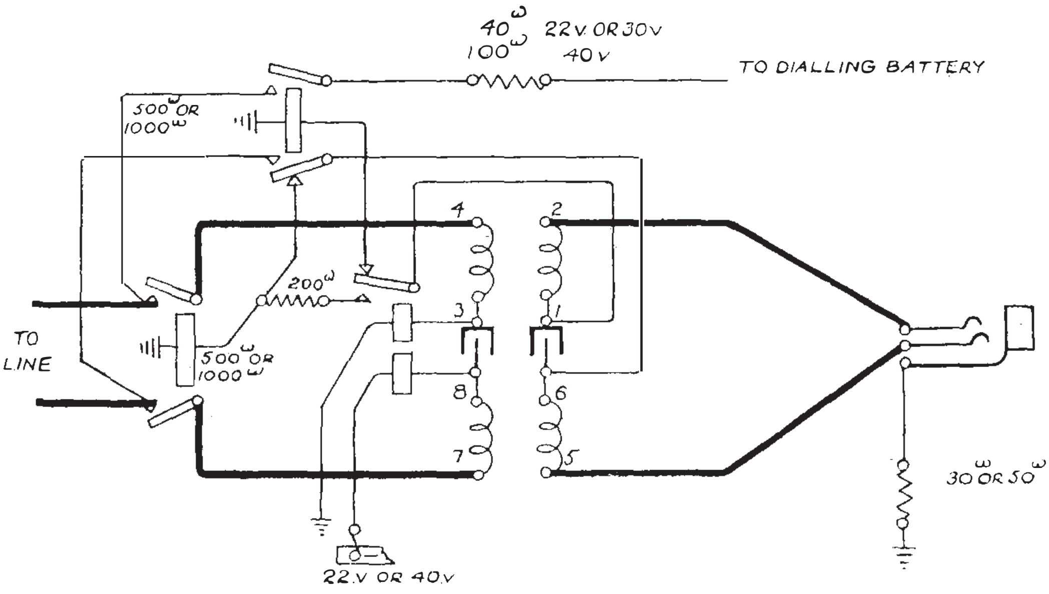


Fig. **13**.—Long Line and Noise Eliminating Equipment.

Tests made on these circuits by the Research Section proved that dialling conditions through equipment to Fig. **13** were improved slightly as compared with direct dialling on a cable line. The disadvantage of additional resistance in circuit is rather more than compensated for by the capacity and inductance tending to lengthen the "make" period, thus correcting the distortion of impulses due to a long line.

The arrangement in Fig. **12** is not so efficient as Fig. **13** for dialling, and gives an average loss of approximately 3.5 miles standard cable. The line limits for battery dialling through equipments to Fig. **13** are approximately the same as shown below. Dialling through equipments to Fig. **12** is 15% to 20% less.

LINE LIMITS FOR BATTERY DIALLING.

Dialling Battery,	Loop Resistances in Ohms.	
22 v.	1200	Speed of dial interruptions at 10 per second.
24 v.	1600	
30 v.	2000	
40 v.	3000	

The foregoing figures are approximately correct, but are dependent (*a*) on the insulation and capacity of the line, (*b*) the speed of the dial impulses. A dial slower than 10 per second decreases the line limits.

MIXED DIALLING.

It has been found necessary to provide for cases where junctions exist from a manual exchange dialling from cord circuits to two different automatic exchanges, one where the conditions permit of " Loop " dialling and the other where " Battery " dialling is required.

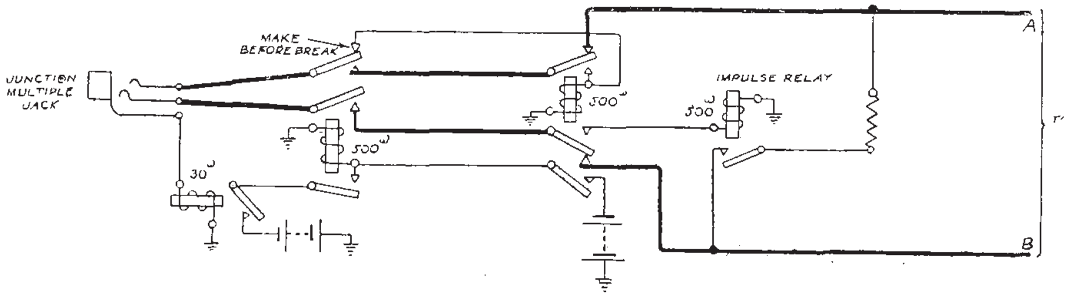


FIG. **14**.—EQUIPMENT FOR CONVERTING " BATTERY " IMPULSES TO " LOOP " IMPULSES.

To meet such cases, two auxiliary equipments have been designed, one to convert " Loop " impulses from the cord circuits into " Battery " impulses on the line and the other to convert " Battery " impulses from cord circuit into " Loop " impulses on the line. The adoption of one or the other of these equipments will be determined by local conditions, economy in apparatus being one of the chief decisive factors.

Fig. **14** shows the auxiliary equipment for converting " Battery " impulses to " Loop " impulses. A portion of this equipment includes the " false impulse-suppressing " feature, shown in Fig. **3**, and in addition a change-over relay (CO) and an impulsing relay (A). The operation of S, by the insertion of the plug, prepares a holding circuit for H. The throwing of the dial switching and dialling keys sends battery over the tip and ring of plug in parallel, as shown in the left portion of Fig. **8**. Relay H is not yet operated and current flows only over the tip side to relay CO, which operates and (1) locks in through its own contact, (2) connects " A " to ring side, and (3) actuates H. Relay H locks in over contact of S and joins the armatures of CO through to jack. Relay A operates and " loops " the line. Dialling commences and " A " breaks the loop in response to the dial impulses. When dialling is completed, the release of the dialling key takes battery off the tip and CO releases. H and S are retained until the plug is withdrawn, A is released by CO and the cord circuit is through to the auto exchange.

The line limits for junctions connected to this equipment are the same as already quoted for " Loop " dialling.

Fig. **15** shows the equipment for converting " Loop " impulses from dial in cord circuit to " Battery " impulses, the conditions at auto exchange end being shown in Figs. **9** and **10**.

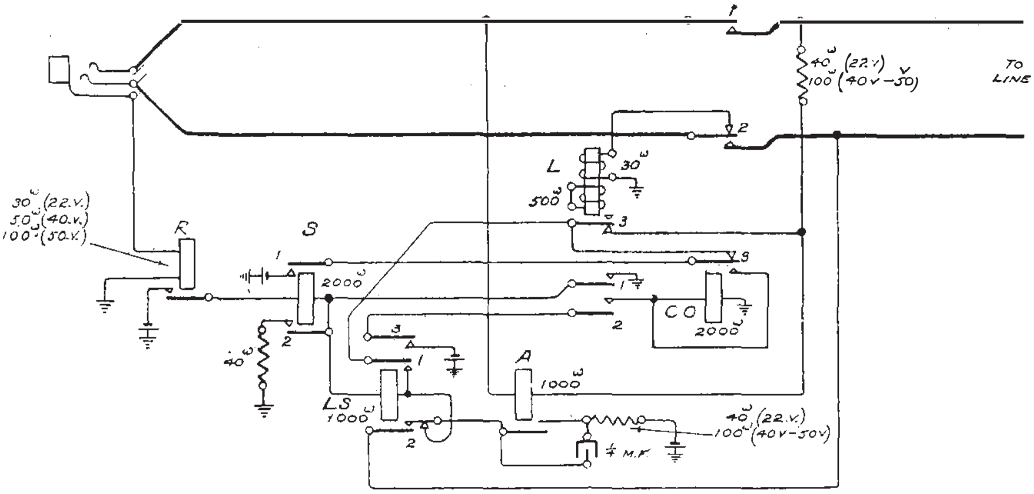


Fig. **15**.—Equipment for Converting " Loop " Impulses to " Battery " Impulses.

When the plug is inserted in the jack, relays R and L operate. Contacts L1 and R1 complete the circuit for relay S, which operates and locks. The dialling key is now thrown and relay L is disconnected from battery and releases, thus completing the circuit for relay A *via* battery, S1, CO3, L3, A1000, through the dialling loop in cord circuit, CO2 to earth through relay L. Relay L is marginal and does not operate when in series with 1000 ohms relay A. Contact A1 completes the circuit for relay LS, which operates and locks up through contacts LS1, CO3 and S1. The " A " line is now connected to battery through 40 ohms, L3, CO3 and S1, while the " B " line is connected to battery through 40 ohms, contacts A1 and LS2. When the dial is operated A will respond to the interruptions and send impulses over the " B " line. On the completion of dialling, the dialling key is released and relay L operates from battery on the cord circuit. Relay CO operates by battery through LS3 and L2 and locks through contacts CO3 and S1. Relay LS is now disconnected at the back contact of CO3 and releases. Relay L also releases, being disconnected by contact CO2, and the circuit is left with relays R, S and CO operated during the talking period.

"Loop" Dialling-in from Magneto Exchanges.

The conditions for dialling-in from these exchanges differ fundamentally from those associated with C.B. exchanges, in that the dial on each position is connected to a special dialling plug instead of being associated with the connecting cord circuits.

Two jacks are provided for each outgoing junction, one jack for dialling and the other for connecting.

The dialling plug circuit is shown in Fig. **16**. This circuit is used both in Magneto and C.B.S. No. 1 Exchanges with more than one position.

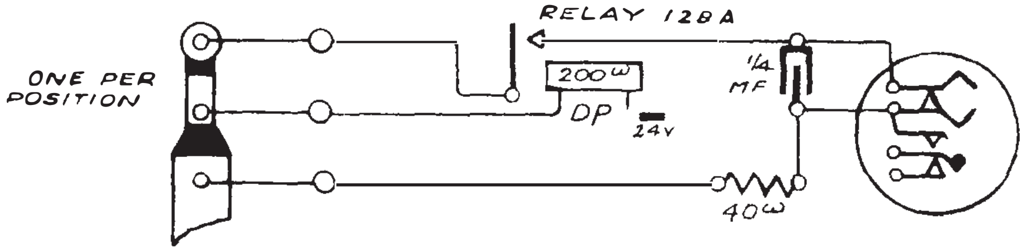


Fig. **16**.—Dialling Plug for Magneto and C.B.S. No. 1 Exchanges.

The function of relay DP is to delay the connection (through dial) between the tip and sleeve until the plug is fully home. This is to prevent false impulses due to contacts between tip, ring and sleeve while the plug is being inserted in dialling jack.

The .25 mf condenser and 40-ohm spool are provided to quench sparking across the dial contacts during impulses.

Multiple Magneto Exchanges (Condensered).

The circuit for unidirectional lines to auto exchanges is shown in Fig. **17**. (Bothway working will be referred to later).

Operations, Loop Dialling.—On getting a demand from a subscriber for a number in auto exchange the operator inserts the calling plug of connecting cord into the outgoing jack of line to auto exchange. Relay CO operates and the selector is "seized" *via* LA to earth. D operates round the loop of waiting magneto subscriber's telephone, by current from DI.

The dialling plug is then inserted. Relay DB operates and CO is released. The required number is then dialled and dialling plug withdrawn. Relay CO re-operates. When auto subscriber replies, LA operates, then C, through contact D (operated) and contact of DB (normal). C locks in through auxiliary spring 4 to earth at spring 3 of outgoing jack. The control of CO is now transferred from the jack to the contacts of LA and D. Relay LA is controlled by auto subscriber and D by magneto subscriber. When both hang up, CO is released and the line is free. This arrangement is to guard against the auto equipment being held up due to slow clearing, owing to the failure of magneto subscriber to " ring off."

In the case of bothway working, it allows a call in the other direction to be made even if a plug be left in outgoing jack. Fig. **17** is designed for either Loop or Battery dialling outgoing only, or for Battery dialling on bothway junctions.

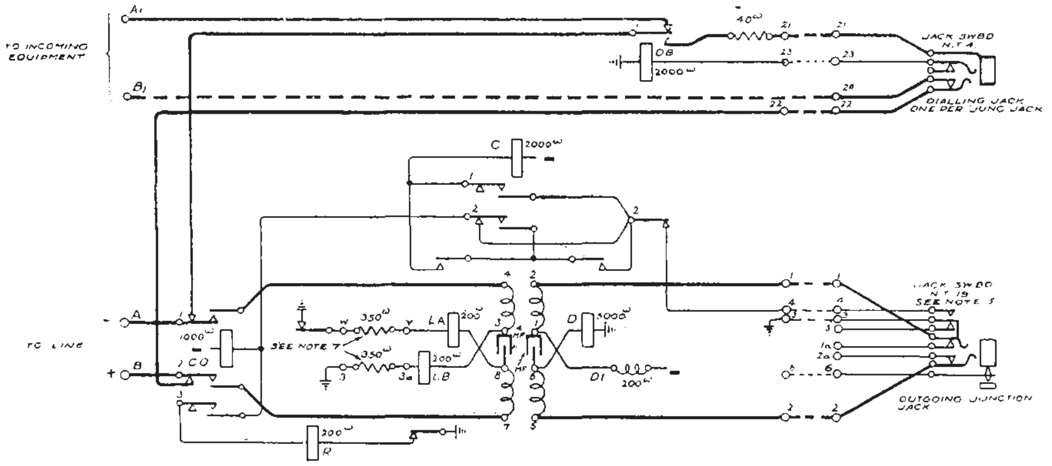


Fig. **17**.—Magneto Exchanges with Condensers. Outgoing: Loop or Battery Dialling; or Outgoing Portion of Bothway Battery Dialling.

The Battery dialling is similar to that described in connection with Fig. **8**, the plug, dialling jack and relay DD performing the functions of the dialling keys. The conditions for Battery dialling at auto end are the same as described for Figs. **9** and **10**.

Bothway Junction—Loop Dialling.

In bothway working, the incoming portions at each end are normally on the line, the outgoing portions being switched in only when a call is begun, and released again at the end of the call. The connections have to be so arranged that the earthed calling relay on the incoming portion of the junction at the manual exchange is not on the same side of the line as the selector coil at auto exchange which is normally to battery. The normal circuit conditions are as in Fig. **18**.

Assuming a call set up by the manual exchange on the outgoing portion and the plug withdrawn before the auto subscriber has replaced the receiver, the reversal would persist and a false call given to the incoming end at the manual exchange. In addition, the selector would be held through the earthed line relay.

Fig. **19** shows the arrangement designed to guard against this probability. It is similar to Fig. **17**, except that LB is a relay instead of a retard coil. An additional contact has been provided on relay CO and an additional relay R has been inserted.

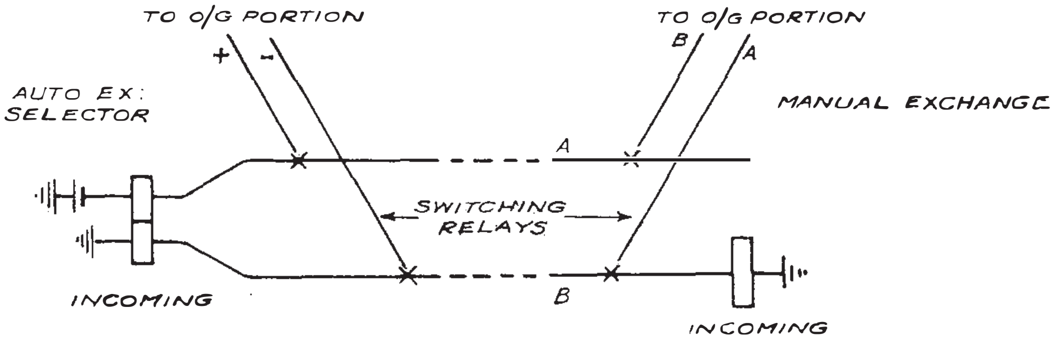


Fig. **18.**

When auto subscriber answers, LA is operated, but LB restores. Relay R is short-circuited by the earth in spring 3 of jack. If the operator withdraws the plug from outgoing jack while the reversal is still on, CO is held in *via* its own contact 3, coil of R to earth at resting contact of LB. Relay R operates in series with CO and disconnects earth from LA. The selector is then released and the reversal is removed. LB operates, R and CO are released and the circuit is at normal.

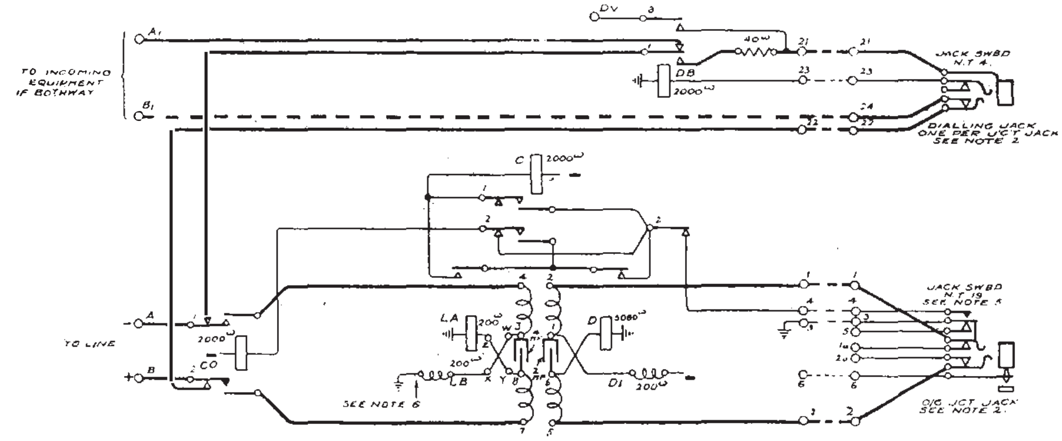


Fig. **19.**—Magneto Exchanges with Condensers. Outgoing Portion of Bothway Junction. Loop Dialling.

Loop Dialling-in from Non-Multiple Magneto Exchanges.

Figs. **20** and **21** show the circuits for use in non-multiple exchanges and are similar to Figs. **17** and **19,** except that the magneto subscriber does not control the release. These circuits are entirely plug-controlled and are designed for exchanges where, owing to the absence of a multiple, there is space for clearing signals associated with the outgoing jacks. These circuits do not require the subscribers' bell circuits to be condensered.

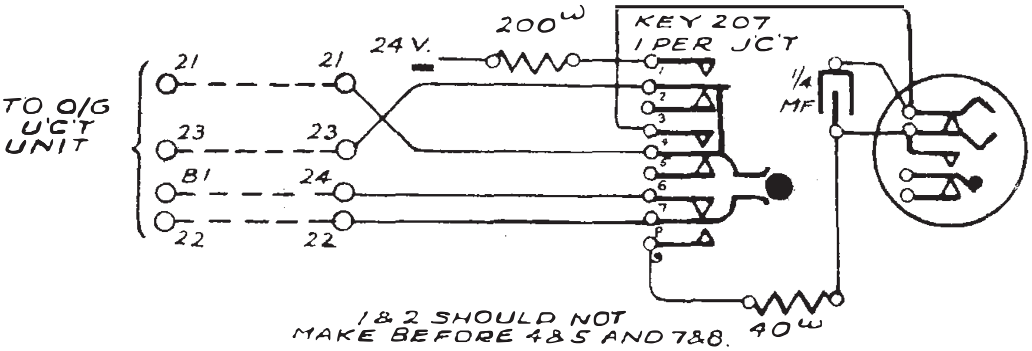


FIG. **20**.—NON-MULTIPLE MAGNETO EXCHANGES. OUTGOING LOOP OR BATTERY DIALLING OR OUTGOING PORTION OF BOTHWAY. BATTERY DIALLING.

In the case of exchanges with one position only, where it is practicable to provide a key per junction, the arrangement shown in Fig. **22** takes the place of the dialling plug and dialling jack.

LOOP DIALLING-IN FROM C.B.S. NO. I EXCHANGES.

These are similar in principle to Figs. **20** and **21**, except that as the operator gets a clear on the cord circuits, there is no need to provide a clearing signal per junction.

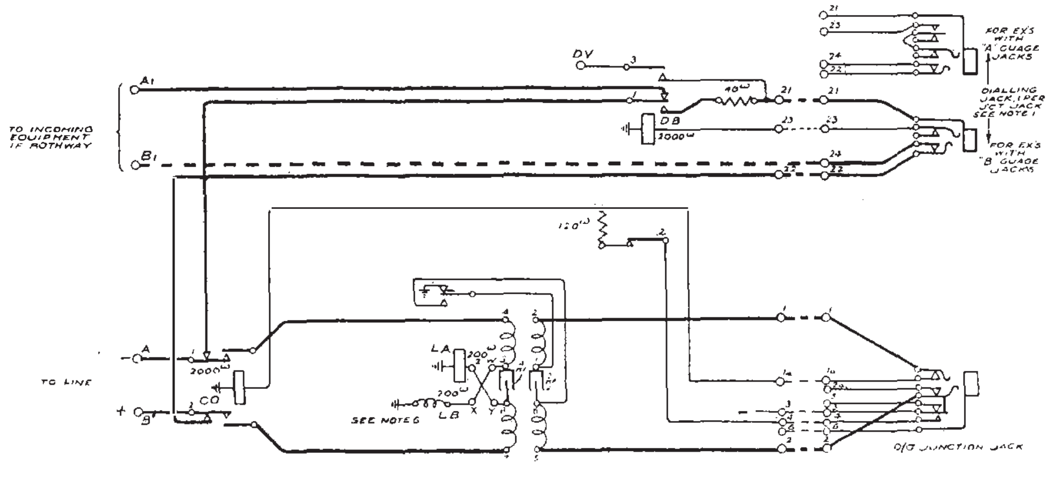


FIG. **21**.—NON-MULTIPLE MAGNETO EXCHANGES. OUTGOING PORTION OF BOTHWAY. LOOP DIALLING.

The circuits are shown in Figs. **23** and **24**. The necessity for the special connections on " A " gauge jacks is to avoid false impulses caused by the tip and ring springs being short-circuited by the tip of dialling plug during insertion.

Fig. **22** can also be applied to C.B.S. exchanges with single positions.

The line limit for " loop " dialling from Magneto and C.B.S. No. 1 exchanges is approximately 1,200 ohms. The limits for battery dialling are the same as already given for C.B. exchanges.

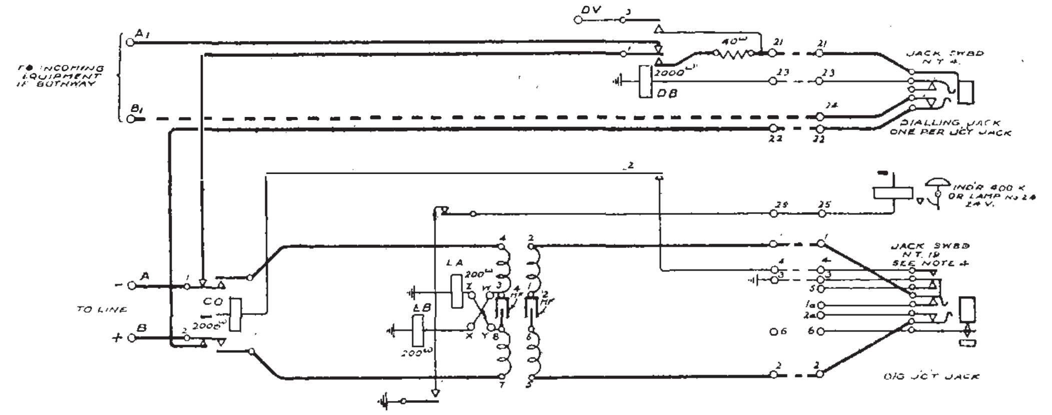

DV
A1
TO INCOMING EQUIPMENT IF BOTHWAY
B1
40ω
21
23
24
22
2000ω
DB
JACK SWBD N.T. 4.
DIALLING JACK ONE PER JCT JACK
2
25
IND'R 400 K OR LAMP No 24 24 V.
JACK SWBD N.T. 19 SEE NOTE 4
A
TO LINE
B
CO
2000ω
LA
200ω
LB
200ω
X
Y
Z
W
1a
2a
6
O/G JCT JACK

FIG. **22**.—MAGNETO AND C.B.S. NO. 1 EXCHANGES. DIALLING KEY PER JUNCTION.

LOOP DIALLING-IN FROM C.B.S. NOS. 2 AND 3 EXCHANGES.

No auxiliary equipment for dialling-in is provided for these exchanges. Dialling will be done from the cord circuits as in C.B. exchanges, and the conditions laid down for C.B. exchanges apply also to C.B.S. Nos. 2 and 3.

As many of the C.B.S. Nos. 2 and 3 exchanges are worked by primary batteries, the voltages may vary from 15 to 35. In such cases, battery dialling only is practicable.

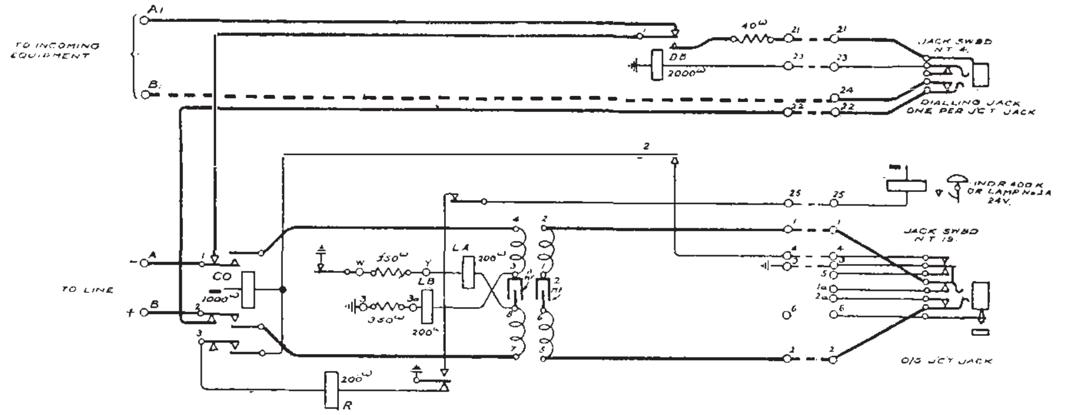


FIG. **23**.—C.B.S. NO. 1 EXCHANGES. OUTGOING; LOOP OR BATTERY DIALLING OR OUTGOING PORTION OF BOTHWAY, BATTERY DIALLING.

BATTERY DIALLING FROM MAGNETO AND C.B.S. NO. 1 EXCHANGES.

In the case of dialling-in to systems where the line relay is connected to earth or where dialling-in repeaters, as shown in

Figs. **9** and **10**, are used, it is necessary to connect the coils or relays LB, in Figs. **17**, **20** and **23**, to battery instead of earth as shown.

In such cases the dialling battery is connected to the point DV, shown in Figs. **17**, **20** and **23**.

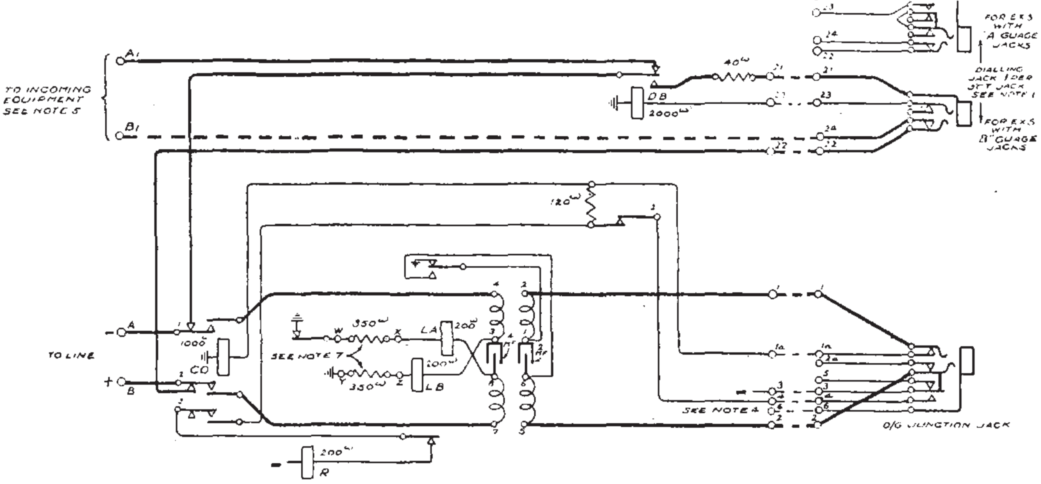

A1
B1
TO INCOMING EQUIPMENT SEE NOTE 5
TO LINE
A
B
1000ω
CO
350ω
W
X
LA
200ω
SEE NOTE 7
200ω
Y
350ω
Z
LB
200ω
R
120ω
DB
2000ω
40ω
SEE NOTE 4
FOR EXS WITH "A" GUAGE JACKS
DIALLING JACK 1 PER JCT JACK SEE NOTE 1
FOR EXS WITH "B" GUAGE JACKS
O/G JUNCTION JACK

FIG. **24**.—C.B.S. No. 1 EXCHANGES. OUTGOING PORTION OF BOTHWAY, LOOP DIALLING.

DIALLING-OUT TO C.B. AND C.B.S. NOS. 1, 2 AND 3 EXCHANGES.

Dialling-out from auto subscribers direct to a manual exchange is limited for traffic reasons to exchanges within 5 miles radius from the auto exchange.

The circuit conditions are as shown in Figs. **25** (auto end) and **26** (C.B. end).

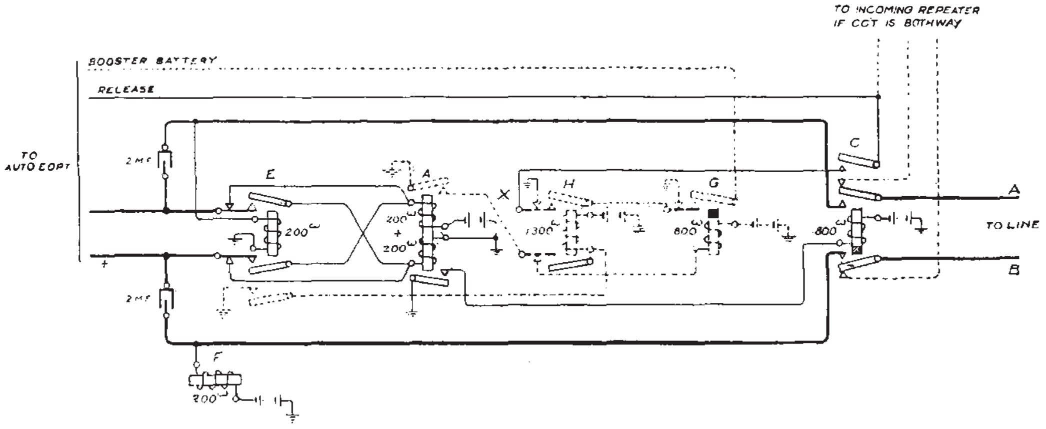


FIG. **25**.—REPEATER CIRCUIT. DIALLING OUT TO C.B. EXCHANGES.

Repeaters to Fig. **25** are connected to selector levels allotted to the manual exchange to be dialled-out, and this equipment takes the place of the final selector on an auto to auto connection.

Operation.—Subscriber dials level required and operates L and G, then CO, which switches the line through. Coil F sends battery over B line of junction and relay D is on A line waiting for called supervisory. When distant subscriber answers, a current is sent on A line and operates D, which reverses the feeding current through L and meters the calling subscriber if the metering circuit is connected for operation on the reversal.

In Booster battery metering, the operation of L also operates the slow release relay G, which prepares the Booster battery to H contact. When D operates, H is actuated and locks in through its own contact 2 and contact 1 of L. The operation of H connects the Booster battery to the release trunk on which the subscriber's meter stands and a call is registered. H also disconnects G and Booster is therefore only applied for the time taken by **G** to release.

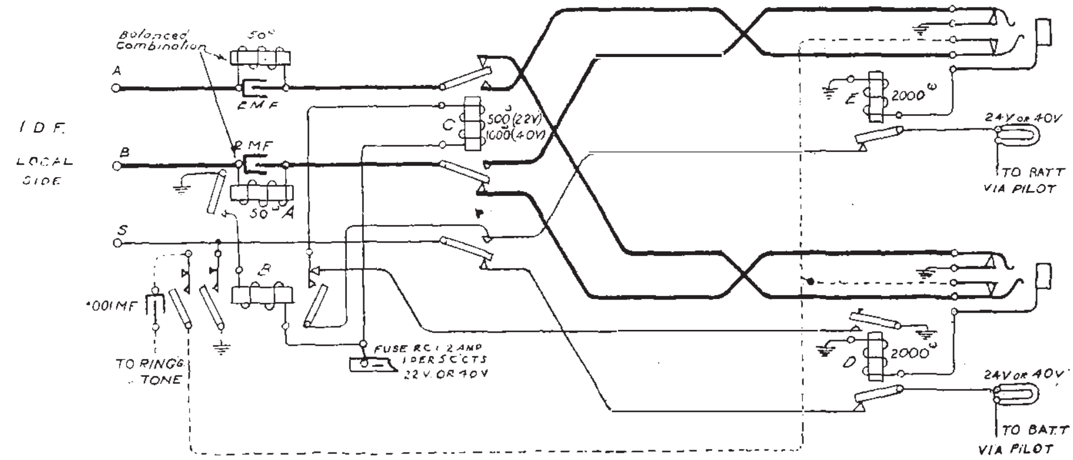


FIG. **26**.—C.B. EXCHANGES. INCOMING CIRCUIT DIALLED OUT FROM AUTO EXCHANGES.

Fig. **26** is designed to free the junction when auto subscriber hangs up and to switch a following-on call to lamp and jack 2, at the same time maintaining a clear on the answering cord connected to jack 1.

Operation.—Relay A responds to current sent over B line; then relay B operates, which sends ringing tone over line, and cuts off the connection from relay S1 to relay C.

Operator gets glow on lamp 1 and plugs into jack 1, which cuts earth off relay A, but that is now in series with the supervisory relay in cord circuit and therefore remains operated. The ringing tone is also cut off at jack.

A jack-ended junction cord circuit is used for connecting this circuit, but is so arranged that current is not sent over A line by the entry of the operator into circuit, otherwise false metering would occur. The metering condition is therefore not set up until called subscriber replies. When auto subscriber hangs up, relays L and CO (Fig. **25**) release, the repeater is freed and a clear given to manual exchange cord circuit.

While the plug is still in jack 1 relay S1 applies earth to relay C, when B releases and C changes over the circuit to jack and lamp 2. A second call following immediately on the release of the first will come up on lamp 2 and will be connected on jack 2, C retaining through test wire T, which is earthed by relay B. The circuit to Fig. **26**, although primarily designed for working from auto exchanges, may also be used for manual to manual working.

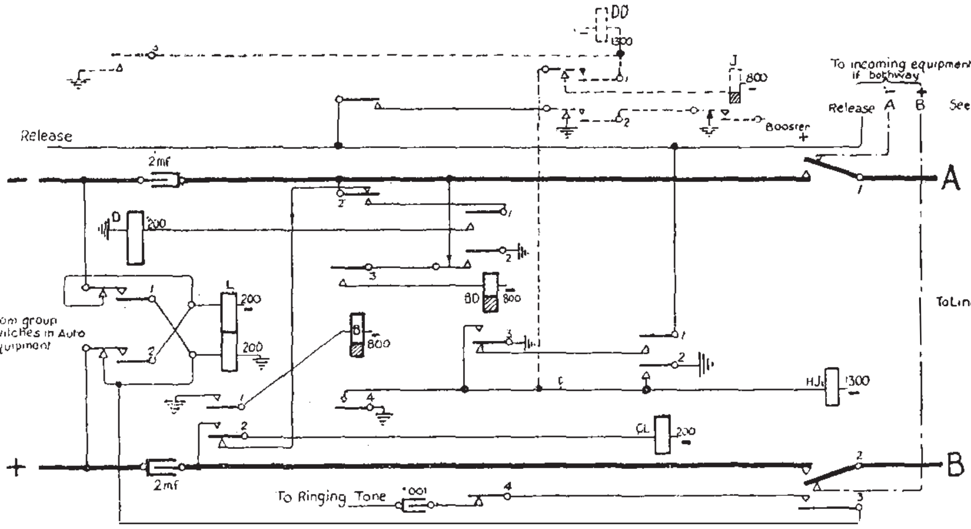


FIG. **27**.—REPEATER CIRCUIT. DIALLING OUT TO MAGNETO AND C.B.S No. 1 EXCHANGES.

DIALLING-OUT TO MAGNETO AND C.B.S. No. 1 EXCHANGES.

Fig. **27** shows the repeater used at the automatic exchange end for dialling-out to Magneto and C.B.S. No. 1 exchanges.

It is the same in principle as the dialling out repeater shown in Fig. **25**, but differs in that the repeater is "held" until operator at manual exchange withdraws the plug. No following-on calls are possible as in Fig. **25**. The "ringing tone" is applied at the auto end because the distant exchanges are not generally provided with ringing machines.

Fig. **28** shows the connections at a Magneto exchange.

Relay LB operates from battery on B line *via* relay F (Fig. **27**) and gives the calling signal. Operator plugs in and sends earth on A line *via* spring 11 of jack, contact M2 and coil of LA. In Fig. **27** relay B had connected relay BD to A line and BD operates by earth from A line on insertion of plug. BD locks and transfers D to A line in preparation for the reply of the Magneto subscriber. Reverting to Fig. **28**, the operator extends the calling plug to the wanted subscriber and rings. The meter key is then depressed. Relay M operates and is locked to earth *via* jack spring 11. M1 connects relays LA and LB together, but earth is still connected at this point *via* contact S1. When the Magneto subscriber replies, S operates, earth is removed from LA and LB and current on B line is looped round *via* A line to relay D on Fig. **27**. The calling subscriber is then metered as described for Fig. **25**.

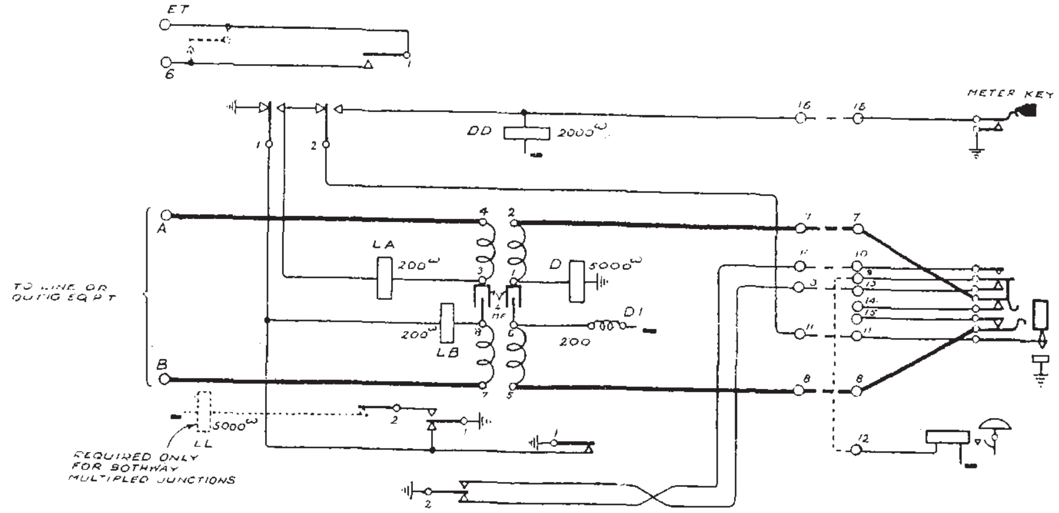


Fig. 28.—Magneto Exchanges. Incoming Circuit Dialled Out from Auto. Exchanges.

Fig. **29** shows the connections for C.B.S. No. 1 exchanges and the operation is the same, except that relay S operates when calling plug is connected to called subscriber and operates DM *via* earth at LB1.

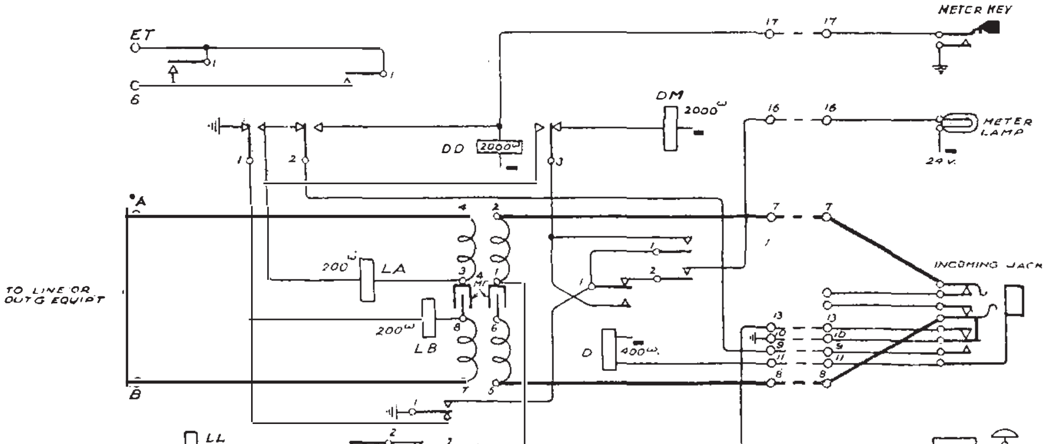


Fig. 29.—C.B.S. No. 1 Exchanges. Incoming Circuit Dialled Out from Auto. Exchanges.

When called subscriber answers, S releases, then DM meter lamp glows, operator depresses meter key, relay M operates and in held *via* contact M2 to earth *via* jack springs 11 and 9.

Relays LA and LB are looped through and calling subscriber is metered as in Fig. **27.** Clearing signals from the auto end are given by the release of LB due to the removal of relay F (Fig. **27**) to the A line. The current on A line keeps LA operated and the outgoing jacks (if bothway) busy until the plug is withdrawn and the consequent release of M disconnects LA and the circuit restored to normal.

PORT OF LONDON AUTHORITY: PRIVATE AUTOMATIC BRANCH EXCHANGES.

By Alec. B. Eason, M.A., A.M.I.C.E.

Section.	*Summary.*
A.	*General Statement of Plant Provided.*
B.	*Various Types of Traffic and Numbering Scheme.*
C.	*Night Traffic Arrangements.*
D.	*Plant at Tilbury: Day and Night.*
E.	*Circuits Bothway Tie Line.*
F.	,, *Alarm Extension.*
G.	*Power Plant.*
H.	*Currents used on Various Calls.*

SECTION A.

THIS article gives a short description of the Port of London Authority's automatic telephone system throughout the various Docks and Offices. The automatic and manual equipment was manufactured to Post Office Specification upon plans and data furnished by Mr. G. F. Preston, C.B.E., M.I.E.E., and installed in 1925 by Messrs. Siemens Bros., Ltd., Woolwich. The following schedule gives briefly an outline of the general scheme:—

Name of P.L.A. Office or Dock.	Equipment for extensions Init.	Ult.	Manual positions provided initially.	Extensions dial out to public exchange.	Inc. calls received *via*
Head Office	200	400	8	Royal	Royal
Tilbury	60	100	1	Tilbury	Tilbury
London & Katherine's	70	120	Nil	Royal	Royal
India and Millwall ...	130	200	Nil	East	,,
Victoria and Albert...	160	250	Nil	Albert Dock	,,
Surrey Commercial ...	120	200	Nil	Hop	,,
Gravesend	Manual P.B.X. with a dial for dialling into the P.L.A. system.				

A detailed description is given of some of the special circuits used in the exchanges, but no attempt is made to describe the ordinary preselector and selector circuits which are of the standard Siemens No. 16 type as used for Swansea, Sheffield, Edinburgh, etc.

The allocation of lines and junctions between the various exchanges is shown in Fig. 1. The figures quoted against exchange lines and junction lines are only approximate; the precise number of channels to and from the public exchanges and between the P.A.B.X.'s will depend upon the requirements at a particular date. The figures given, however, show the general relationship between the various lines and extensions.

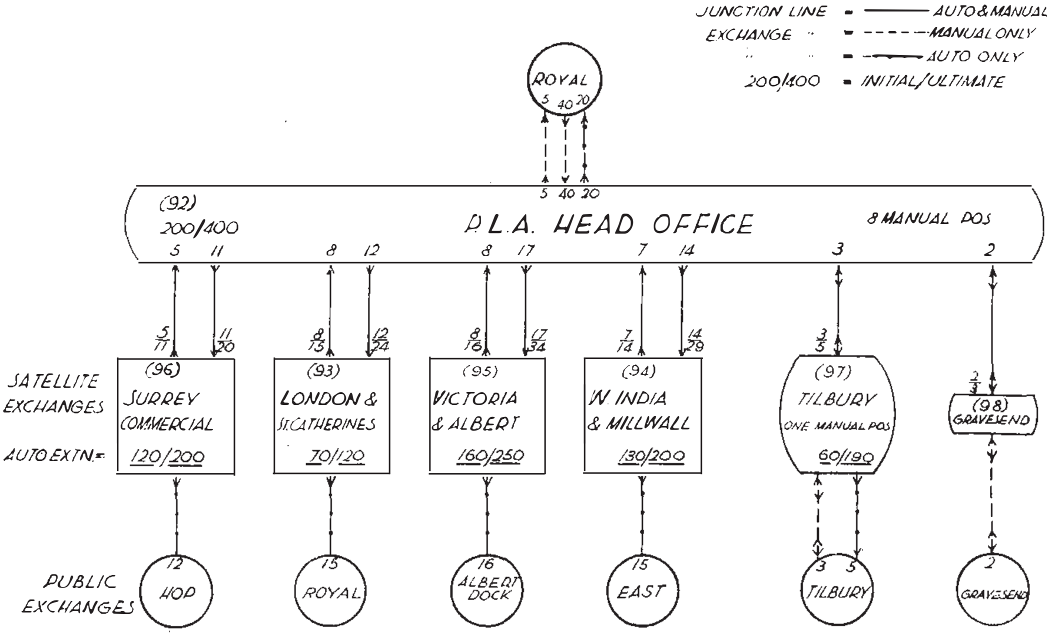


FIG. 1.—P.L.A. EXCHANGES AND TIE LINES.

The multi-office numbering scheme differs from that used for public exchanges, in that only three figures need to be dialled for local calls, whereas five figures are required for inter-exchange calls. This scheme saves the provision of certain plant, and can be adopted because the persons using the telephone are all officials in the one organisation.

SECTION B.—TRAFFIC AND NUMBERING SCHEME.

The traffic to be dealt with falls under the following categories:

Outward calls, an extension calling the following:—

Type.	*Direction.*	*Type.*	*Level used.*
Local,	to an extension on same Exchange.	Auto	2, 3 or 4
Inter-Ex.,	to an extension on a Satellite.	ditto	92 to 97
,,	to an extension at Gravesend.	Auto-manual	98
Public,	to a member of the public, *via* a local or junction call.	ditto	0
,,	to a member of the public, *via* Trunk or Toll exchange.	ditto	91
Local,	to the P.L.A. manual board for an enquiry.	ditto	91

Incoming calls.

Incoming from the public; any type, trunk or local, etc.	to an extension at the Head Office or Tilbury.	Manual	The P. L. A. operator plugs into the extension line multiple on the Manual positions.
Ditto.	to an extension at a Satellite.	Manual-auto	The P. L. A. operator plugs into o/g junc. and dials the No. required.

The difference in procedure between day and night calls is described in Section C.

A typical numbering scheme, to give the above mentioned facilities is given below. This refers to Surrey Commercial Docks; at other exchanges the numbering is similar.

Level.	*Purpose.*
1	Spare: N.U. tone.
200—299	Extensions: Surrey Commercial: local calls.
300—399	,, ,, ,, ,, ,,
4	Spare: N.U. tone.
5	,, ,, ,,
6	,, ,, ,,
7	,, ,, ,,
8	,, at Surrey Commercial. (At Tilbury, 8 calls Tilbury Manual board).
91	P.L.A. Manual board at Head Office.
92200—92599	Extensions at Head Office.
93200—93319	,, ,, London and St. Katherine's Docks.
94200—94399	,, ,, India and Millwall Docks.
95200—95449	,, ,, Victoria and Albert Docks.
96200—96399	,, ,, Surrey Commercial (when called from other exchanges).
97200—97299	,, ,, Tilbury Docks.
98	Gravesend manual P.B.X.
99	Spare: N.U. tone.
90	,, ,, ,,
0	Public Exchange.

If the caller wants some information, or some enquiry is to be made, the procedure at first is the same as for trunks; "91" is dialled and the PLA operator will give the required information.

The PLA operator can complete local calls to the extensions, if the caller finds it difficult to get the extension required; the caller dials 91 and asks the PLA operator to dial the number and complete the call for him; or the call can be completed later when the wanted extension becomes free. In the case of Head Office extensions the operator can repeatedly test the multiple jack, until she finds it free and can then plug in and call the line which has been busy, and then recall the extension which originated the call.

Incoming Calls from the Public System circulate either from Royal Exchange to the PLA Head Office or from Tilbury Exchange to the PLA, Tilbury Docks. At the Head Office manual board, the local extensions are multipled and if the call is for a Head Office extension the operator plugs in direct, no automatic plant being used for the call. For calls to the satellites the operator plugs into a disengaged line in the outgoing junction multiple of the inter-office junctions which radiate from the Head Office to the various docks. These junctions also come from the levels of the 2nd selectors and terminate upon 3rd selectors at the satellite exchanges.

The method of busying junctions so that a 2nd selector will not pick up a junction which an operator is using, and so that the operator will find the engaged test upon the outgoing junction multiple jack, if an automatic call is in progress is explained in Section E, dealing with a *bothway* junction. In that case there are four channels which have access to the one line, viz., auto extensions at either end, and operators at either end; anyone of these which takes possession of the line must busy it to the other three.

We shall discuss the handling of calls in more detail.

Local Calls circulate *via* 1st and 2nd preselectors to 1st selectors and then *via* final selectors to the required extension.

If the call is to a *satellite*, it reaches a 2nd selector at the Head Office, when 9 is dialled, and reaches a 3rd selector in the exchange required *via* a two-wire junction, or *via* a direct three-wire trunk in the case of calls to the Head Office when the 2nd digit is dialled: the remaining three digits of the extension wanted are then dialled and pick up a final selector and the required extension.

Calls to Gravesend are completed manually after the P.B.X. operator at Gravesend has been reached by dialling 98; the manual board taking the place of 3rd selectors at the other docks.

Local and Fee Junction Calls to the public can be made by dialling " 0 "; junctions from this level go direct to the relative public exchange and the public exchange operator makes the connection and meters the call, as in the case of an ordinary subscriber.

Trunk and Toll Calls to or from any extension must be dealt with by the PLA operator so that the payment may be controlled, and the call when it matures may be circulated to the calling extension. As all inward traffic comes into the Head Office, except in the case of Tilbury, naturally outward trunk traffic must take the same route. The caller dials 91 and gets the attention of the PLA operator.

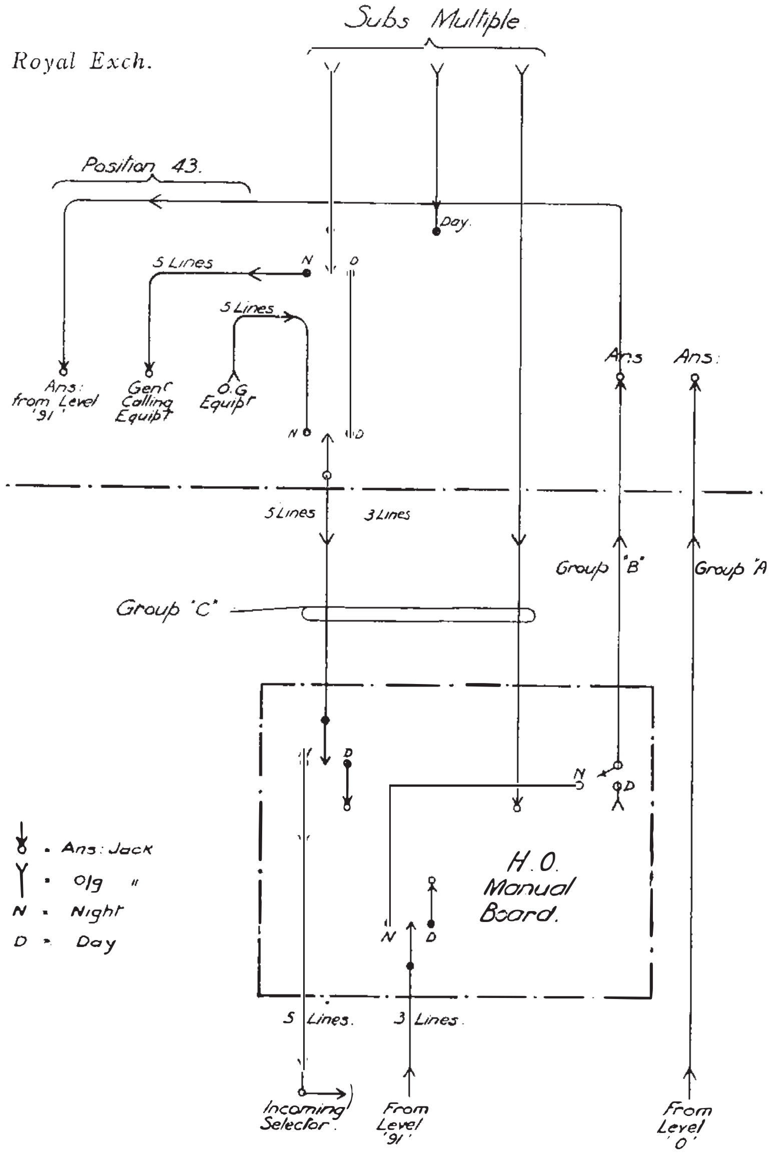


FIG. 2.—P.L.A. HEAD OFFICE LINES TO ROYAL EXCHANGE.

SECTION C.—NIGHT SERVICE ARRANGEMENTS. (FIG. 2).

The night arrangements at the Head Office and at Tilbury are similar and only those at the Head Office will be described. The main feature is that the P.O. operator at Royal will dial PLA extensions when the subscriber's PABX operators are not on duty.

The lines from the PLA to Royal Exchange consist of three groups, A, B and C.

Group A consists of lines carrying outward local and junction traffic from the Head Office extensions to Royal Exchange, obtained by dialling "o."

Group B consists of lines worked manually from the Head Office to Royal.

Group C consists of lines from Royal to the Head Office, several of which are switched to apparatus at night to carry night traffic.

An extension wanting a trunk call at night dials 91, as is done during the day, but the call arrives at a special position at Royal, having been transmitted over one of Group B lines to answering equipment on a special position at Royal. The Royal operator completes the Trunk call in the ordinary manner.

Calls being made to the PLA at night are put through on the subscribers' multiple as during the day, but as the lines are now intercepted the call is received on answering equipment at the special position in the same exchange, where the Department's operator can complete them by dialling into the PLA system. She plugs into special outgoing jacks at Royal which are connected to the lines of group C, arriving at PLA Head Office on incoming selectors: she then dials the five digits of the required extension number whether it be at the Head Office or at one of the Docks. The caller must be in a position to ask for the particular dock and particular extension number required.

SECTION D.—PLANT AND TRAFFIC ROUTES AT TILBURY DOCKS.

This exchange has one manual board and 60 extensions. The local calls are dealt with as in other exchanges.

The junction traffic is dealt with *via* three routes:—

1. *Via* "o" level circuits *to* the Tilbury Public Exchange.
2. *Via* manaul bothway junctions to and from Tilbury Public Exchange.
3. *Via* manual and auto junction lines to the Head Office for traffic in the PLA system.

There are three "o" level lines, which are not allowed trunk facilities. If an extension wants a trunk call, 8 will be dialled and the call will arrive at the PLA manual board. The operator will book and pass the call to the Tilbury Public Exchange over a bothway manual exchange line.

Incoming trunk calls to Tilbury Docks will come over the trunk lines to Tilbury Public Exchange and be passed *via* the bothway exchange lines to the PLA board.

When extensions require information from their own operator, they will dial "8," and the call will arrive at the manual board.

Fig. **3** shows, schematically, the grouping of plant at Tilbury. The 60 auto extensions come to break-jacks on the manual board and thence to 1st Preselectors. The banks of 1st Preselectors go to 1st Selectors. On level 2 are the final selectors for auto calls incoming to auto extensions. Manual calls are connected direct *via* the break-jack on the manual board.

On level " 0 " is the auxiliary equipment for calling the Tilbury Public Exchange.

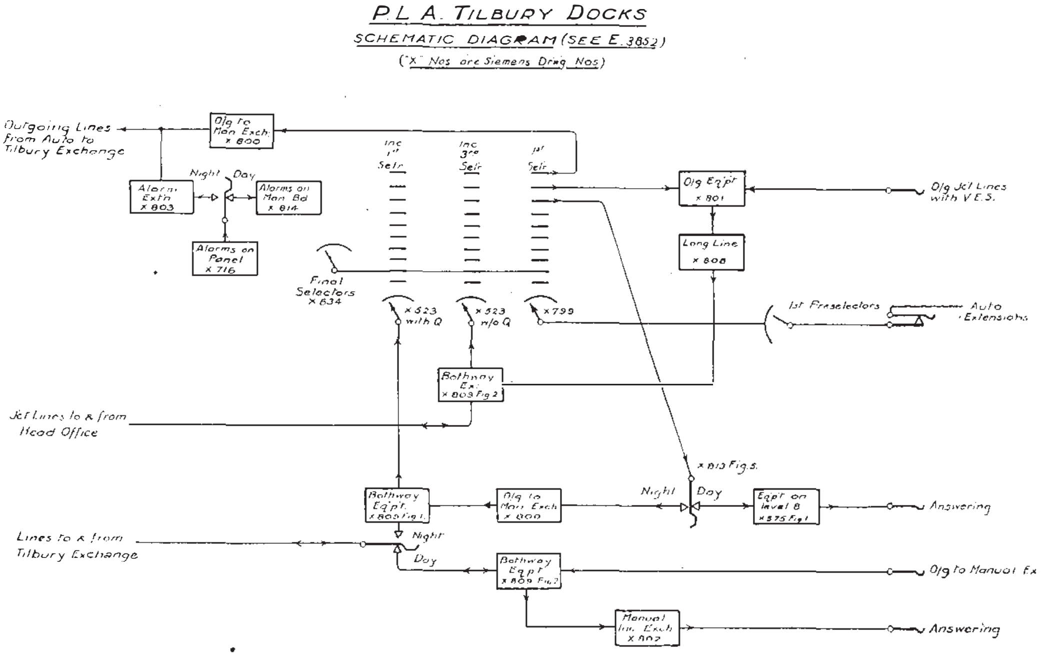


FIG. 3.—P.L.A. TILBURY DOCKS. SCHEMATIC DIAGRAM.

On level " 9 " is the equipment for calling the other PLA exchanges, *via* the tie lines: the manual board operator has access to these same tie lines *via* o/g jacks equipped with manual engaged signals. The bothway equipment busies the manual board jacks and relative bank when the tie line is being used for an incoming call.

On level " 8 " during the day, the call goes *via* auxiliary equipment to the answering jack on the manual board, and at night to the Public Exchange. (See below).

The exchange (manual) lines terminate on ordinary bothway equipment and answering jacks at the PLA manual board.

The traffic arrangements at night are as follows:—

The PLA operator before she leaves will throw night switching keys which

(1) Change over the manual exchange lines to (*a*) incoming 3rd selectors for incoming calls, and to (*b*) circuits from level 8 so that when extensions dial " 8 " for trunk

calls, the call will be received by a special operator in the public exchange who will control inward and outward calls for the PLA.

The routing is as follows: from level 8 *via* key to equipment for calling the public exchange, *via* bothway equipment to cut off the incoming selector *via* the other key to the public exchange.

Incoming calls come from Public Exchange *via* key and bothway equipment to an incoming selector.

The public exchange operator must dial the three figures of the extension number required.

(2) The night keys also throw over an alarm circuit so that faults occurring at night will give the alarm by lighting lamps at Tilbury Public Exchange instead of lighting lamps on PLA manual board.

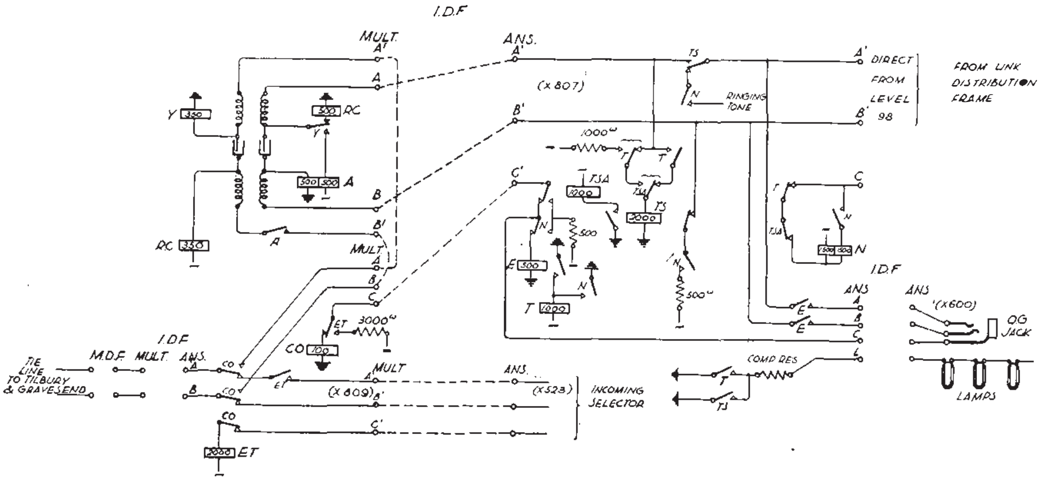


FIG. 4.—P.L.A. BOTHWAY EQUIPMENT ON TIE LINES. HEAD OFFICE.

SECTION E.—BOTHWAY JUNCTION LINE CIRCUIT.

The bothway junction line circuit between the Head Office and Tilbury or Gravesend is shown in Fig. 4. Its circuit operation is as follows:—

The Gravesend operator making a call takes possession of an incoming selector and dials the number required. The outgoing junction multiple and the banks of the 2nd selectors on level 98 are made busy so that the junction cannot be taken up simultaneously for calls from the Head Office to Gravesend.

The PLA operator making a call to Gravesend plugs in on the outgoing junction multiple, engages the banks on the level 98 and cuts off the incoming selector. Similarly, an automatic call to Gravesend will engage the outgoing junction multiple and cut off the incoming selector.

We shall first describe the operations for a *manual call* from the PLA operator to *Gravesend.*

(*e* = energised, *d* = de-energised, *h* = held, T′ = *via* a contact of T energised, ′T = *via* a contact of T unenergised or normal).

The operator plugs into the outgoing junction multiple

E *e* from the sleeve circuit.
CO *e* ,, ,, ,, ,,
T *e* *via* E and lights the visual engaged lamps and also cuts off battery from private of bank contact which is therefore busy.
The incoming selector is cut off at CO′.
A *e* in long distance equipment, by battery sent out on B line from cord circuit.
Battery is sent out on B line to Gravesend from the retard RC (350), *via* A′ and the Gravesend operator is called.
The Gravesend operator replies : and puts
Y *e* Battery on the A line and operates Y.
TS *e* Battery *via* A (500), Y′, repeater, A line, T′, ′TSA, TS (2000), earth.
TSA *e* *via* TS′.
TS joins the A line through to the cord circuit and extinguishes the supervisory lamp.
TS *h* Battery, 1000 ohm resistance, T′, TSA′, TS (2000), earth.
TSA keeps the battery from the private of the banks and keeps them engaged and TS keeps the visual engaged lamps alight.
The banks and outgoing junction multiple are thus kept engaged as long as either the Gravesend operator or the PLA operator has a plug in the line jacks.

Now consider the operations for an *automatic call to Gravesend* when the tie line is picked up automatically at the Head Office when someone has dialled 98.

The wipers of the 2nd selector wipe over the banks marked A′, B′, C′, and if the tie line be free, battery N (1500) operates the test relay.

N *e* the 2nd selector and relay N operates.
M *h* by earth on the private wire of 2nd selector.
T *e* *via* N′.
T lights the visual engaged lamps.
CO *e* Battery, 500 ohms, N′, ′TSA, ′ET, CO (100), earth.
CO cuts off the incoming selector.
N puts battery *via* 500 ohms on to B line and N puts ringing tone to the caller.
A *e* operates A.
A joins battery *via* RC (350) to the B line to Gravesend.
When Gravesend operator replies the actions of TS and TSA are as previously described.

The relays and retards energised during a conversation automatic call to Gravesend and supplied with battery from the Head Office are : —

Relay.	*Ohms.*	*Amperes.*
CO	500 + 350 ohms	0.0706
RC	350 + 23 + 800 line + 50 Gravesend	0.0490
A	500 + 23 + 500	0.0686
N	1500 + 1500	0.0200
T	1000	0.0600
TS	1000 + 2000	0.0200
TSA	1000	0.0600
Lamps,	150 (in circuit)	0.2500
	Say 0.60 Amp.	0.5982

Current will also be used in the 2nd Selector originating the call to Gravesend and Gravesend will supply battery *via* A wire to hold Y (350).

Now consider a call *from Gravesend.* When the Gravesend operator plugs in, battery on the B wire operates on a relay in the incoming selector : A relays pulls up V, which earths the C wire. This pulls up ET.

ET puts the A line through.

ET puts the engaged test on the *o/g* jack.

E *e* from ET and lights the visual engaged lamps.

T *e* from E, and engages the bank on level 98 by cutting off battery so that no auto call can be received.

Gravesend then dials in the ordinary way and the call will go through automatically to its destination.

During a call from Gravesend the current used is :—

Relay.	*Ohms.*	*Amperes.*
ET	2000	0.0300
E	3000 + 500	0.0171
T	1000	0.0600
Lamps	150	0.2500
		0.3571

Current used in incoming selector (X523) :—

A	from Gravesend	
HA	500 + 23 + 800 + 50	0.0435
V	500 + 1000	0.0400
V	500 + 300	0.0750
RA	350 + 500	0.0706
T	1500	0.0400
		0.2681

SECTION F.—ALARMS AT H.O. AND TILBURY.

When a fault occurs a lamp glows to indicate its position and type, and a pilot relay causes a lamp on the manual board to glow. The various faults are grouped under two headings, " urgent " an " non-urgent," and actuate either an " urgent " pilot or a " non-urgent " pilot relay. Fig. **5** shows the circuits which are used for extending the alarm to the manual board and the public exchange.

During the day any fault simply causes a lamp to glow on the manual board and the operator advises the maintenance staff of its occurrence.

At night time the existence of urgent faults is made known to the public exchange operator over a junction used ordinarily for traffic, but which can be taken up, if idle, by the fault signalling arrangements.

At night time the existence of non-urgent faults is not *signalled* to the public exchange.

If an operator wishes to find out whether or not a non-urgent fault exists, she can dial a particular number allocated for "faults," and if the number is busy a fault exists.

If everything is in order the operator would receive N.U. tone on that particular number: the busy condition is put on by the break in the C wire, due to operation of either H or B relays.

During the day the key is normal and the operation of a pilot relay lights the lamp on the manual board.

When the PLA operators leave the manual board the key is thrown. A non-urgent fault will then actuate H and put busy on the particular "fault" number.

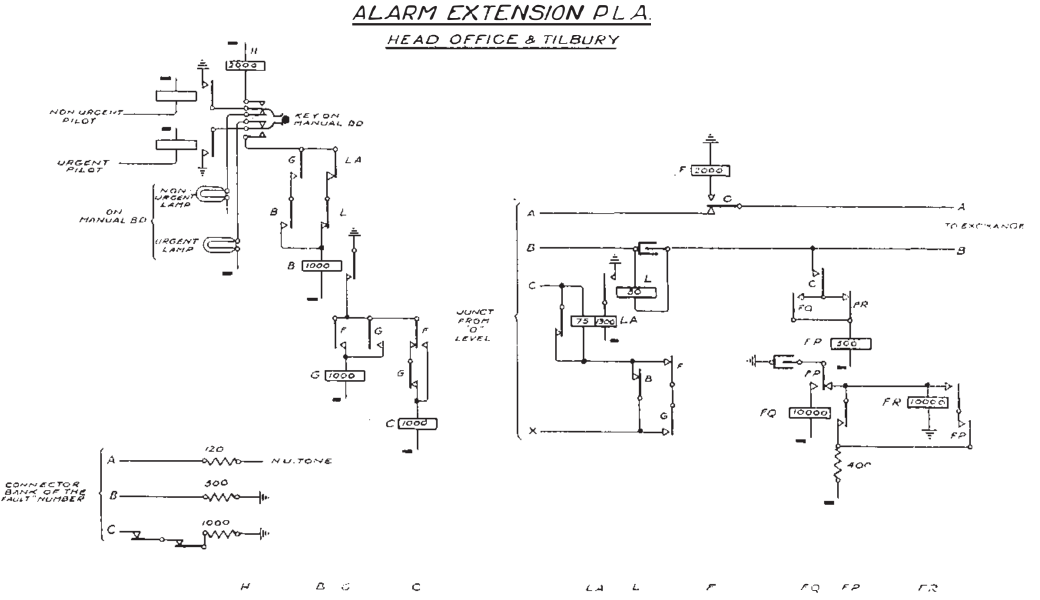


FIG. 5.—ALARM EXTENSION P.L.A. HEAD OFFICE AND TILBURY.

The circuit description of an urgent fault at night is as follows:—

(*e* = energised, *d* = de-energised, V = battery 'L = *via* L armature, normal, L' = *via* L armature operated).

Urgent Alarm. Fig. 5.

Assuming the junction to public exchange is idle.

B *e* V, B 1000, 'L, 'LA, contact of Alarm relay, earth B relay disconnects private of cct. allotted for fault discrimination at B' making it test busy to the operator when she tests.

C *e* V, C 1000, 'G, 'F, B', earth.

C relay disconnects A line to auto. equipment and connects the A line to F 2000.

FP *e* V, FP 500, 'FR, C', B line, Exchange earth.

FQ *e* By condenser charge.

FR *e* When FP is operated, relays FW and FR are operated alternately *via* FR', 'FQ and 'FR, FQ', thus giving an intermittent flash at the exchange.

F *e* When the operator answers she puts battery on the A line and operates F.

The lamp in the B side of the cord circuit will flash.
F relay brings in G relay.
G *e* V, G 1000, F′, B′, earth.
G *h* G relay locks itself; *via* G′ B′, earth.
C *h* C relay is now held *via* F′ instead of ′G.
When the operator withdraws her plug, the lamp flash stops because,
F *d* at withdrawal of plug
C *d* at ′F and this cuts FP off the B line.
The A line is re-connected to the Auto. equipment at ′C: and the junction is available for ordinary traffic.
Relay G is now held operated *via* G′ and B′.
Relay B is operated all the time the fault exists, *i.e.*, whilst the "urgent" Pilot Alarm relay is operated.
The operator can test if the fault is still on, by testing the predetermined extension number which will test busy whilst the fault exists.
Should the junction be engaged when the Alarm originates, then
L *e* *via* the junction loop
LA *e* V, LA 1300, L′, earth: now B relay cannot operate until the junction is free.

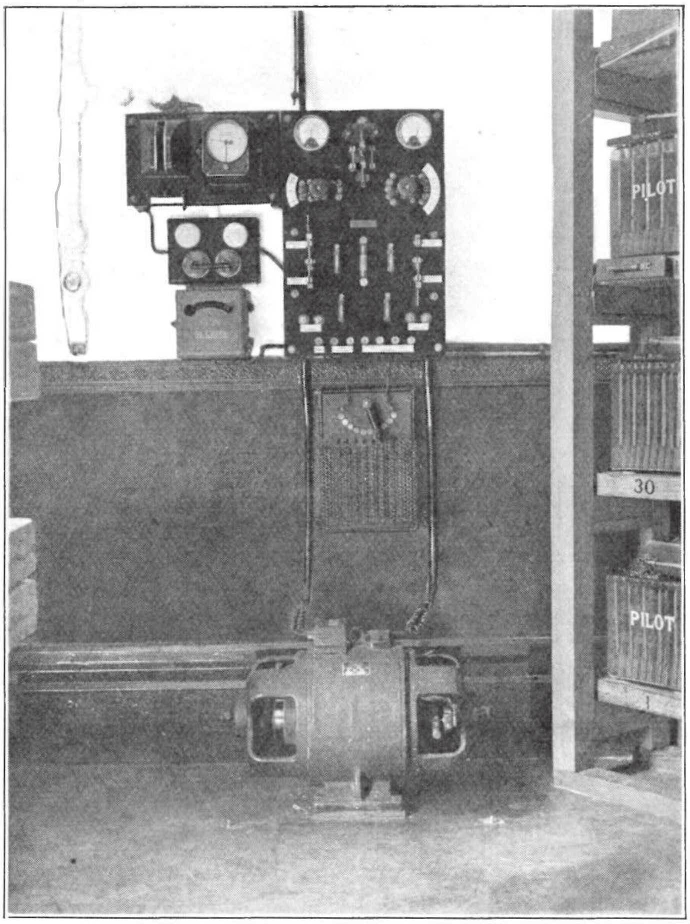


FIG. **6**.—CHARGING PLANT AT SURREY COMMERCIAL DOCKS.

SECTION G.—POWER PLANT.

The Power Plant provided for the satellite exchanges is of the standard Post Office type. Fig. **6** shows the installation at Surrey Commercial Docks. It comprises (*a*) the charging machines consisting of a 230-volt motor coupled to a generator giving 20 amperes at 60 volts with voltage regulation from 60 to 82 volts: (*b*) the charging panel, and (*c*) the ampere-hour meter which cuts off the charge when the requisite charge has been given to the cells. The pointer of the A*h* meter is set at a certain point by the officer who starts up the charging machine; when the full charge has been given to the cells, the pointer makes an electrical contact which actuates the no-volt release of the starter and the charging machine stops running.

In every exchange there are duplicate ringing machines, arranged so that if one fails to supply the current, the other machine will start up and supply the ringing current. The machines comprise (*a*) the ringer, (*b*) the interrupters for giving the busy back and number unobtainable tone, and (*c*) the interrupters for supplying impulses at 60 and 30 per second for driving the preselectors and selectors.

It is Messrs. Siemens' usual practice in small exchanges to provide one machine to give all the interrupted currents needed. In large exchanges they provide separate machines to give ringing interruptions and switch drive interruptions.

SECTION H.—CURRENT CONSUMPTION.

This section gives the current consumption for some typical calls, during conversation period. Dialling and ringing periods are not considered.

Consider four types of calls from a satellite, say, Surrey Commercial Docks:—

(*a*) To Public Exchange, "o."
(*b*) To a local extension.
(*c*) To an extension at Head Office.
(*d*) To an extension at India and Millwall Docks.

Consider three types of call at the Head Office:—

(*e*) Incoming from the Public Exchange to Head Office extension.
(*f*) Incoming from the Public Exchange to a Satellite (IM).
(*g*) From a Head Office extension to a Satellite (IM).

The first selector supplies currents backwards to feed the calling extension: the amount of current fed forwards depends upon whether the current goes (*a*) to the Public Exchange, (*b*) to feed another extension, (*c*, *d*) over a junction line to the Head Office.

For (*a*) the exchange line is taken as 100 ohms, and relay to earth in cord circuit as 200 ohms, total resistance is 700 ohms (86 *m*A).

For (*b*) the extension loop is taken as 150 ohms, giving a total 850 ohms (70 *m*A).

For (*c, d*) the junction line resistance is taken as 100 ohms, giving a total 973 ohms (62 *m*A), with a 23 ohm repeater in series with 500 ohms.

The C wiper circuit differs in the various cases: for calls going outside the exchange the wiper has to find battery to prove that the junction is idle: battery through 1000 ohm, C wire resistance, is put on the private, which becomes earthed when a selector picks up the junction. For local calls the battery is supplied *via* the private wire of the final selector.

The ampere-hours for 2 minutes duration calls are thus:—

	a	*b*	*c*	*d*	*e*	*f*	*g*
At	SC	SC	SC	SC	Ex.	Ex.	HO
	to	to	to	to	to	to	to
	Ex.	SC	HO	IM	HO	IM	IM
Head Office	0	0	.014	.017	.010	.018	.021
Surrey Commercial ...	.013	.015	.012	.012	0	0	0
India & Millwall ...	0	0	0	.012	0	.012	.012

A MODERN TELEPHONE REPEATER STATION.

THE principal members of the net-work of modern high efficiency telephone cables connecting all the important towns of Great Britain have now been completed, and as far as these towns are concerned insurance against total interruption of communication by storm and tempest is as complete as modern scientific methods can make it. The general design of the cable network was described by Sir William Noble in his paper before the Institution of Electrical Engineers in 1921. The routes of the main cables and the location of the repeater stations are given in Fig. 1.

The time required for building and equipping the Repeater Stations has proved to be longer in nearly every case than the time taken to complete the cables converging on them. In addition to the delays unavoidably connected with the purchase of sites and the placing of building contracts there have been several periods of delay due to strikes in the building trade. Where, however, it has not been possible to complete a main Repeater Station by the time the converging cables were ready for service a temporary installation of repeaters has been provided to avoid loss of revenue. The temporary installation has generally consisted of one or more emergency sets which are kept normally in readiness at convenient points in the country for use in case of fire and other contingencies.

The purpose of the present article is to describe one of the modern permanent Repeater Stations which constitute a new feature in any considerable network of underground telephone cables. These stations are located at average intervals of 50 miles along the cable routes. The actual location of any station has been dependent on several factors, the primary considerations being the maintenance of a uniform power level along the cable lines, the focussing points of cable routes and the availability of a reliable source of public power supply. The locations of stations such as Derby, Leeds, or Birmingham is evidently fixed by their position on the cable routes; whereas stations such as Marlborough or Jedburgh have been located by the first condition mentioned. In cases such as the two last named the stations are necessarily self-dependent as regards power supply and have their own prime movers. Otherwise they conform to the general design which has

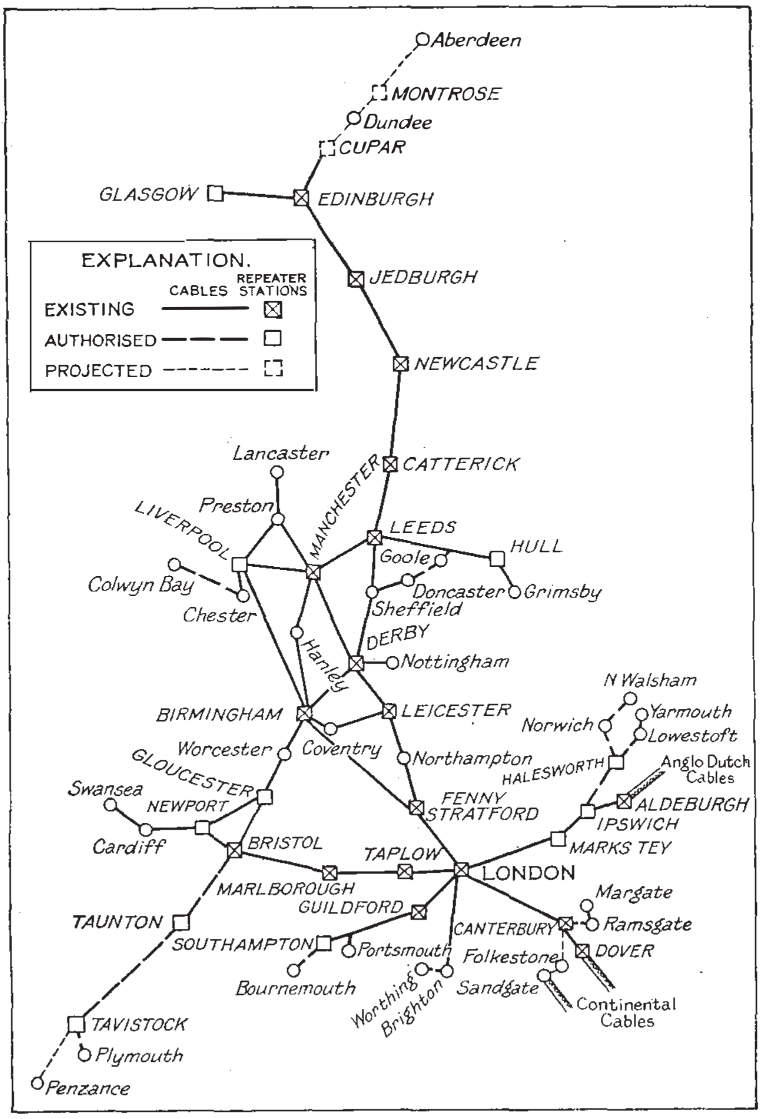


FIG. 1.—TELEPHONE REPEATER STATIONS—PLAN OF SYSTEMS.

been standardised for the whole system. The stations to which the following description applies in detail are those at Taplow and Marlborough on the London-Bath main road. These were the first of the series of permanent stations to be completed and may be taken as fully representative of the whole series.

Taplow station stands on a plot of about two-fifths of an acre, with a frontage of 85 feet to the main road. The buildings, which were designed by and erected under the supervision of H.M. Office of Works, are plain brick structures of two floors in fireproof construction throughout. The roof is flat. The ground floor accommodates the prime movers, generators and batteries; the upper floor is taken up almost entirely by the repeater room. Ample staff accommodation is provided on both floors. A low pressure water heating system is installed, with the boiler in a basement alongside the cable entrance chamber. In spite of its not altogether prepossessing external appearance, the well-lighted and ventilated interior presents a very pleasing effect, and it would be difficult to imagine more pleasant conditions in which to work. Figs. **2** and **3** are photographs of the Marlborough and Taplow Repeater Stations. In some of the later and more isolated stations residential accommodation in the form of a 5-roomed flat has been added. Continuous attendance will be given in all the main line repeater stations.

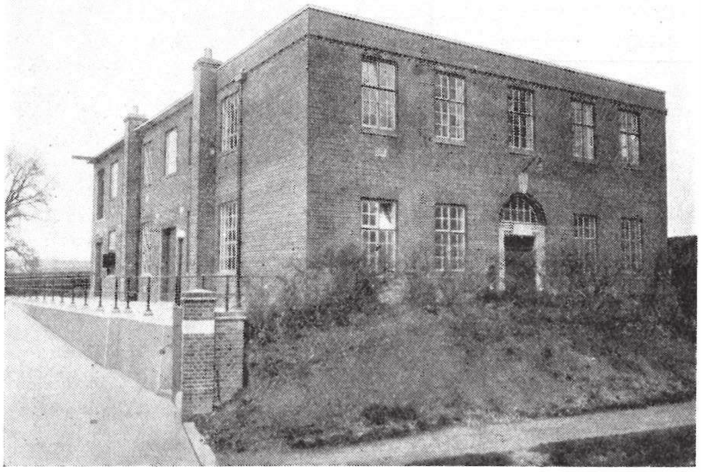


FIG. 2.—MARLBOROUGH STATION.

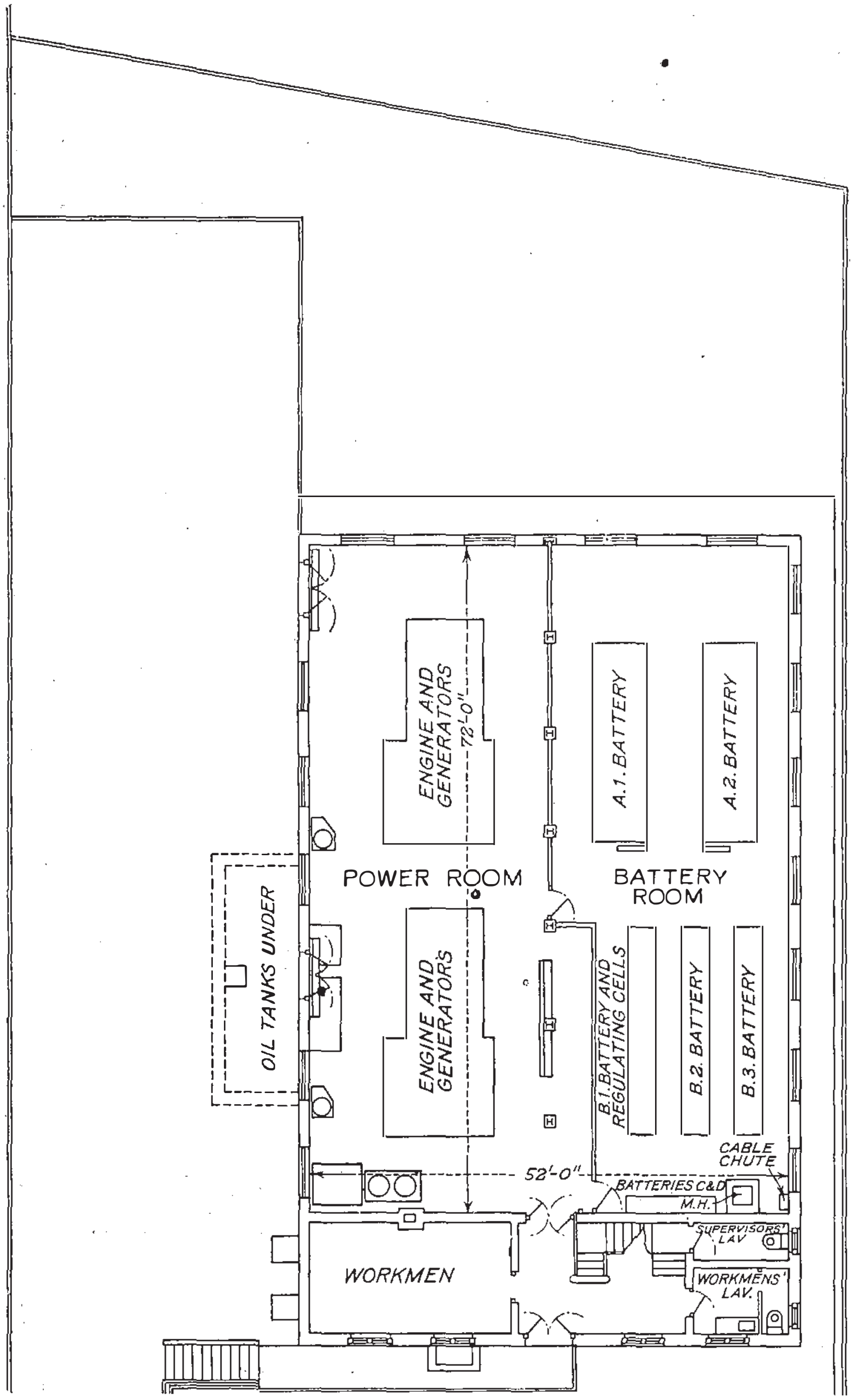
The site of the Taplow station is large enough for a building of sufficient proportions to accommodate all the repeaters needed for operation of the cables for which ducts have been laid along the route. In general along the main routes 3 ducts have been laid for long distance cables. Taking the average circuit capacity per cable (including phantoms) as 330, an ultimate of 1,000 repeaters is arrived at. The proportions of the initial buildings were determined primarily by examination of traffic estimates which resulted in a standard layout for 520 repeaters, sufficient in most cases for a 10-year period.

The standard lay-out of the two floors is indicated in Fig. **4**.

It will be convenient in the first place to trace the course of a two-wire cable circuit through the Repeater Station by reference to Fig. **4** and photographic illustrations.

FIG. **3**.—TAPLOW STATION.

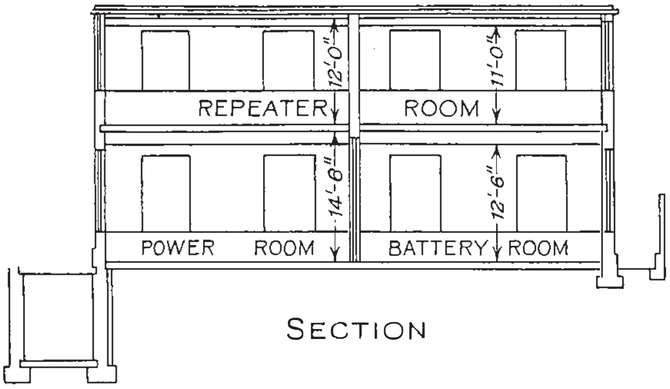
The main cables are turned into the building from a roadway manhole astride the duct line and enter the cable turning chamber in the basement. They rise from this chamber vertically to the Repeater Room to a point 2 or 3 feet above floor level (Fig. **5**). At this point, each main cable (in this case each cable contains 154 quads, multiple-twin formation) is divided by means of a pothead into 7 subsidiary cables for convenience in handling. The air space and paper insulation of the main cable is unchanged in the extension cables. The extension cables are carried along above the Terminal Test Tablet Racks, where each cable in its turn is terminated in a pothead from which emerge a corresponding number of V.I.R. tails. These tails are led down to the back of the Test Tablets and soldered to pillar terminals. The cable



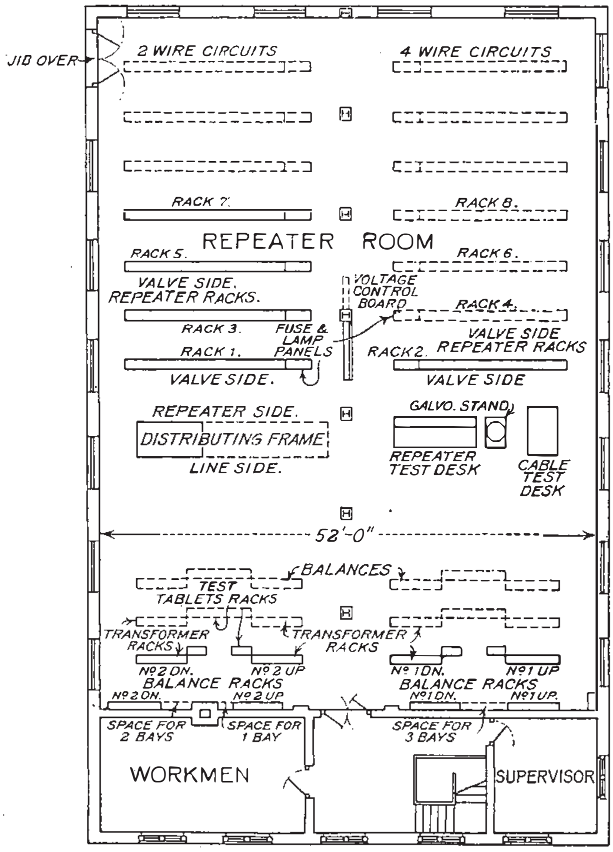
GROUND FLOOR PLAN

Fig. 4.—Standard Lay-out of the

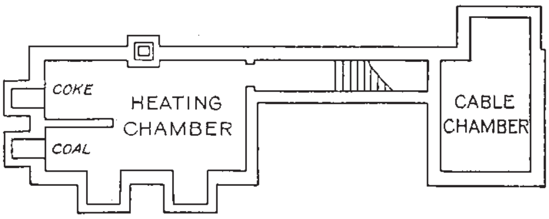
A MODERN TELEPHONE REPEATER STATION.



SECTION



FIRST FLOOR



BASEMENT PLAN

TWO FLOORS AT THE REPEATER STATION.

conductors are thus completely sealed between the Test Tablet Terminals of successive stations along the cable route, and an insulation resistance of 10,000 megohms per mile is the minimum admitted.

The cable circuits are extended from the Test Tablets to the Terminal Transformers, seen at the bottom of the rack in Fig. **5**, by means of V.I.R. The Test Tablets are to be seen at the right of the Transformer Rack.

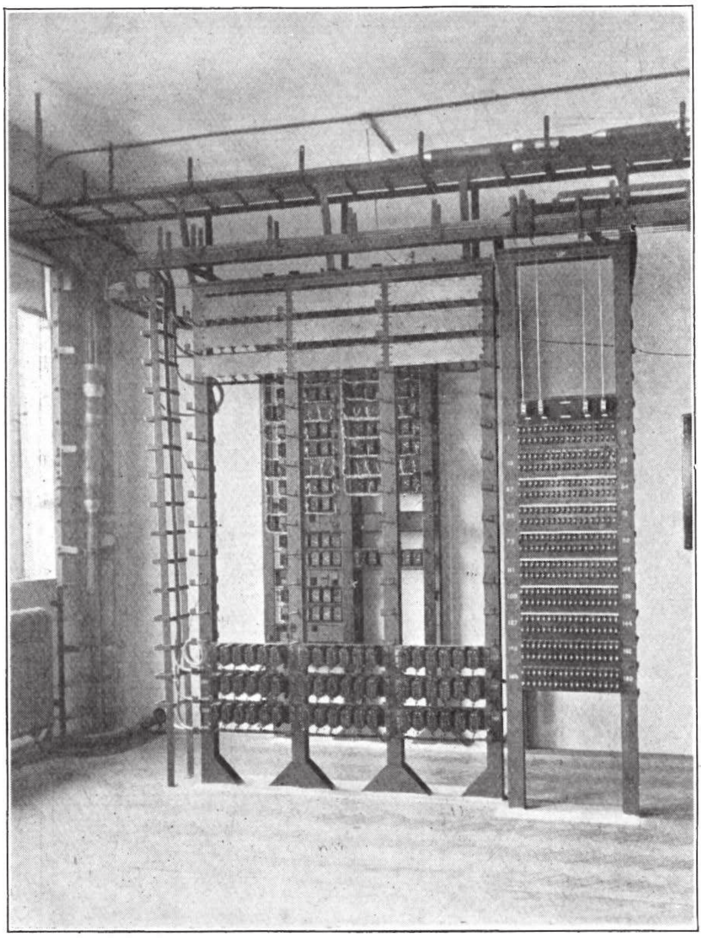


FIG. **5**.—ENTRY OF MAIN CABLES TO REPEATER ROOM AND TERMINAL TEST TABLETS.

Two-Wire Working.—A group of 3 pairs of transformers is allotted to each cable quad; one pair for each physical or side circuit and one pair for the superposed or phantom circuit.

Of each pair of transformers one takes the line circuit and its companion the balance circuit. The object of pairing the transformers, which is done by careful selection after manufacture, is to ensure that the line and balance transformers present the same impedance characteristics at speech current frequencies, that is, between 300 and 2,000 cycles per second, this being the

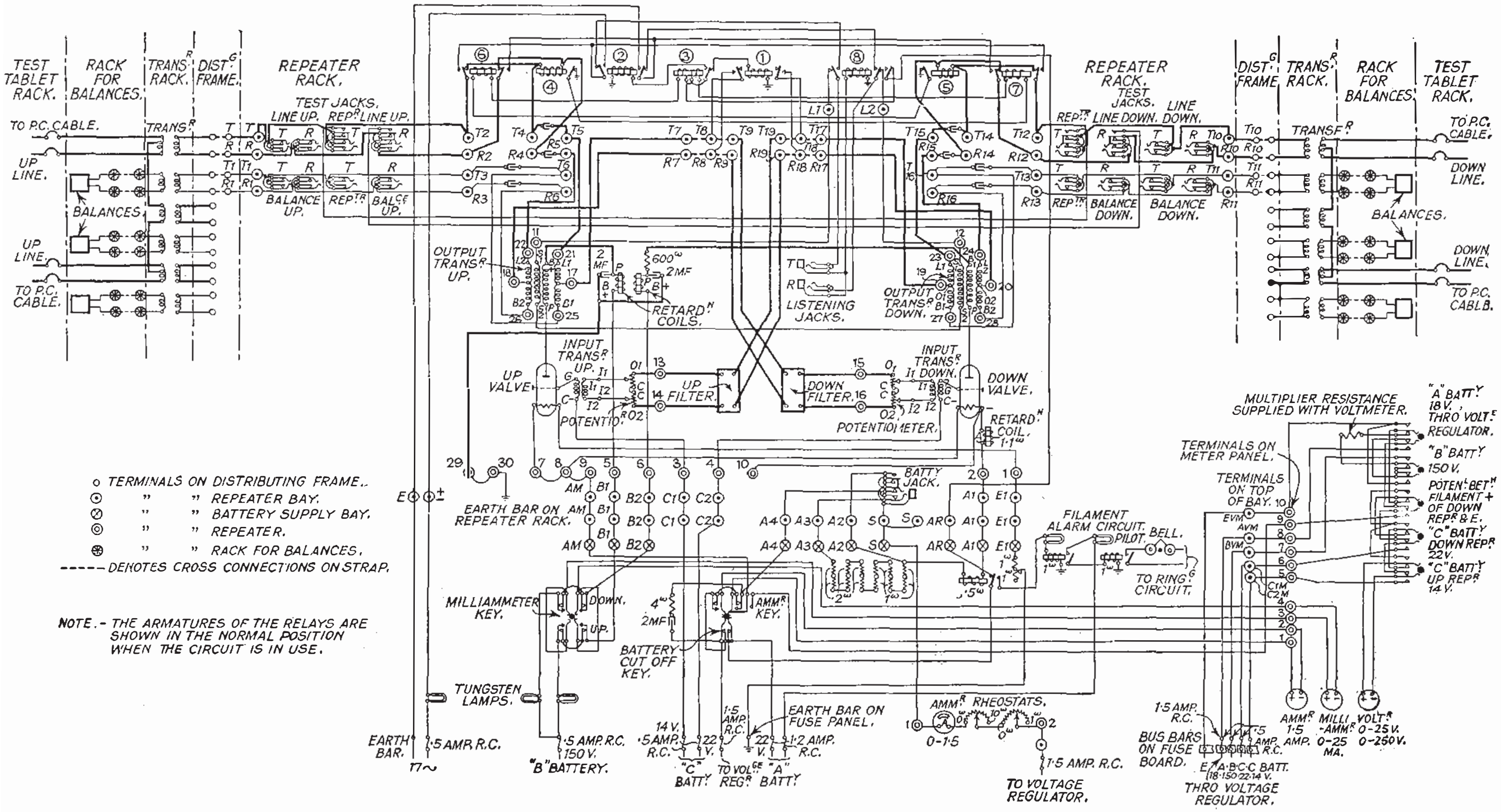


FIG. 6.—TELEPHONIC REPEATER STATIONS: 2 WIRE, 2 VALVES, 1 STAGE WITH REPEATER NO. 10 COMPLETE CIRCUIT DIAGRAM.

maximum range normally provided for in 2-wire circuits. The wiring arrangement of the transformers is clearly shown in the diagram Fig. **6**. From the Transformer Rack the cable circuits, physical and phantom, are carried to the Distribution Frame (Fig. **7**) in lead-covered silk and wool insulation cables, each cable carrying 9 circuits.

The wiring diagram (Fig. **6**) shows one of the physical circuits of a quad through the station, but physical and phantom circuits are precisely similar inside the station. The circuits are distributed from the D.F. to the various Repeater Racks in small lead-covered cables, terminating on tags at the head of each bay (Fig. **8**). From this point we must consider separately the speech and signalling circuits. The former can be traced along the heavy lines in the wiring diagram. The 2-wire repeater is illustrated separately in Figs. **9**, **10** and **11**.

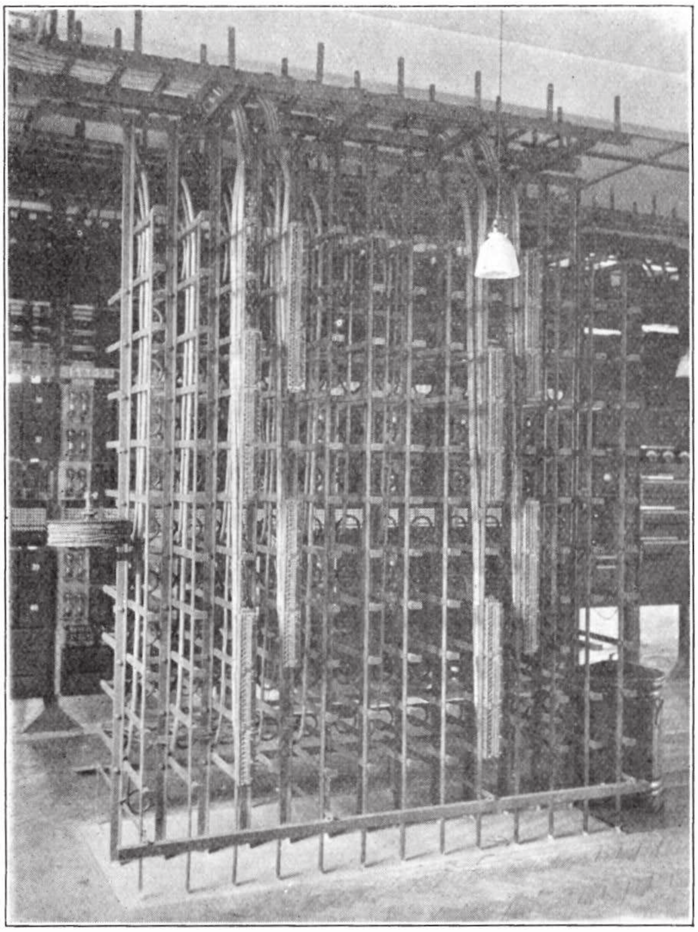


FIG. **7**.—DISTRIBUTION FRAME.

It will be seen that it is necessary to take the speech circuit through the contacts of ringing relays before it passes *via* the

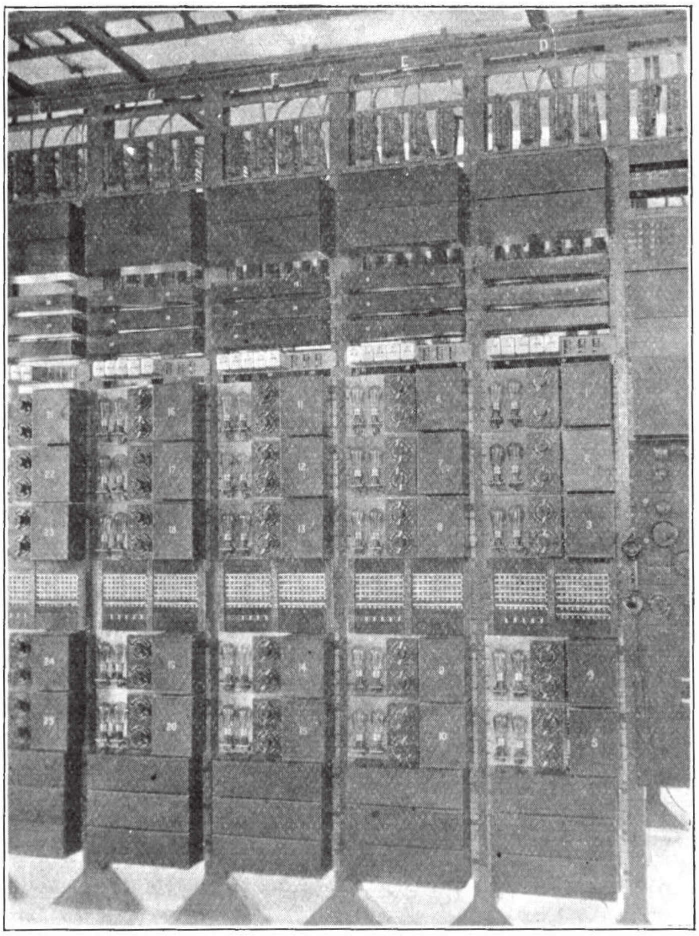


Fig. 8.—Repeater Bays.

Differential Output Transformer to the opposite Input Transformer.

The balancing network, which consists of a network simulating as closely as possible the impedance characteristics of the actual

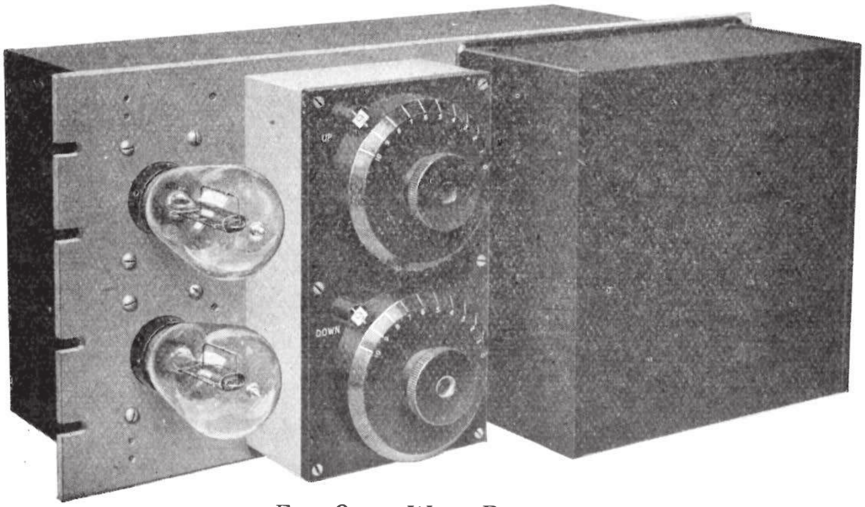


Fig. 9.—2-Wire Repeater.

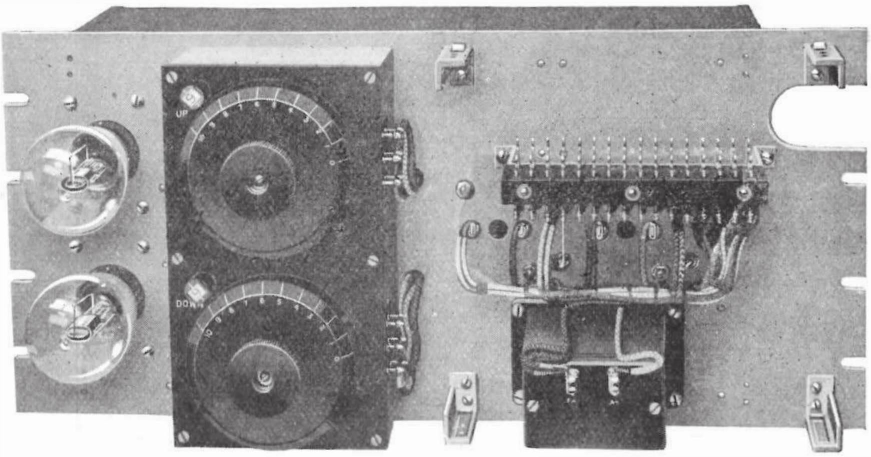


FIG. **10**.—FRONT VIEW WITH DUST COVER REMOVED.
2-WIRE REPEATER.

cable line, is connected in series with the line windings of the Differential Transformer. The networks are accommodated on a rack fitted close up to the Terminal Transformer Rack and the whole arrangement is so designed that the line and balance circuits are electrically identical between the Repeater Rack and the Terminal Rack.

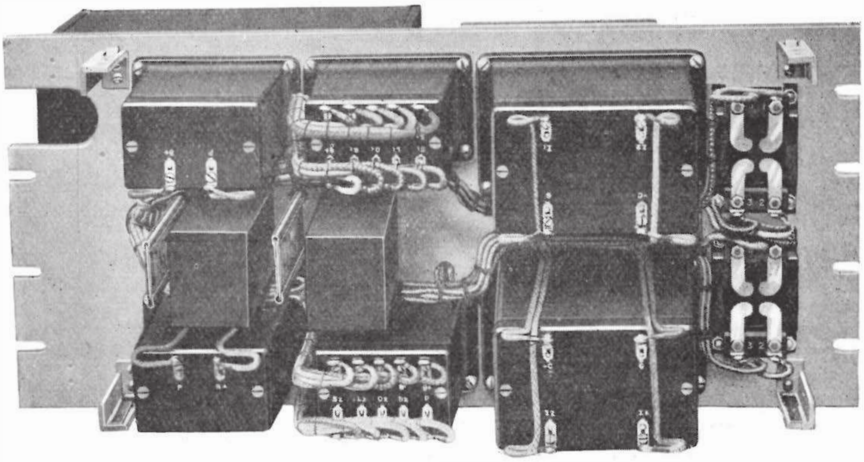


FIG. **11**.—REAR VIEW WITH DUST COVER REMOVED.
2-WIRE REPEATER.

A typical balancing network for a physical circuit in the

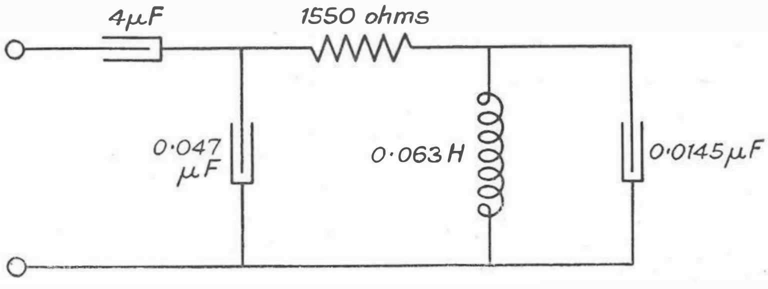


FIG. **12**.—BALANCING NETWORK FOR SIDE CIRCUIT—TAPLOW REPEATER STATION.

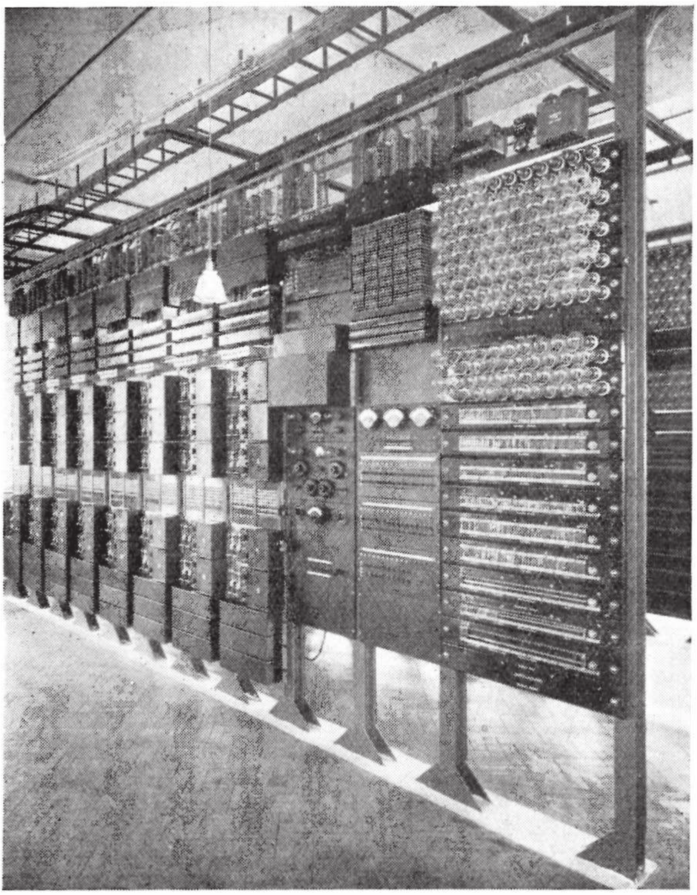


FIG. **13**.—REPEATER RACK FRONT.

London-Bristol cable at Taplow is shown diagrammatically in Fig. **12**. These networks are designed on the basis of actual measurements of the line impedances.

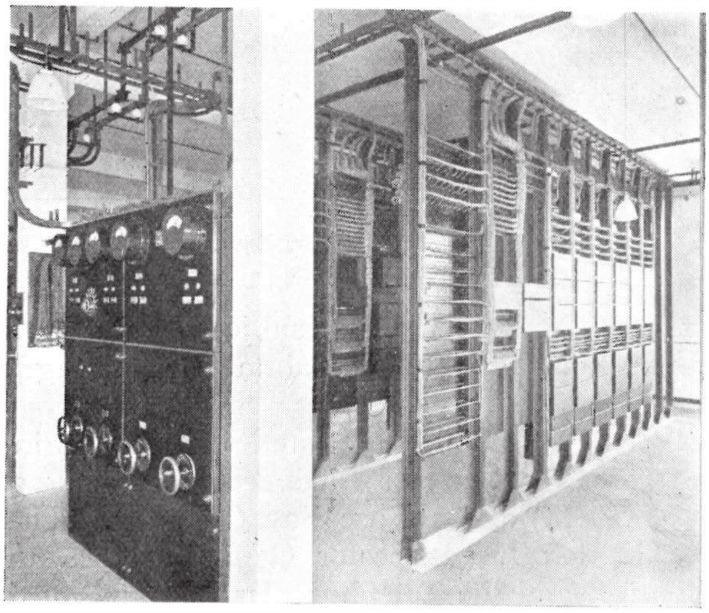


FIG. **14**.—REPEATER RACK REAR.

From the middle points of the Up differential transformer the speech circuit passes through the Down filter to the potentiometer controlling the grid circuit of the Down Valve. The plate circuit of this valve transmits amplified speech currents to the Down line *via* the Down Differential Output Transformer, the wiring from this point to the cable Terminal Transformers being precisely similar to the wiring of the Up line side.

The theory and performance of a 2-wire Telephone-Repeater having been frequently described in the pages of this journal, it is not necessary to enlarge on the subject in this article. Some details of the controlling and maintaining arrangements may, however, be of interest.

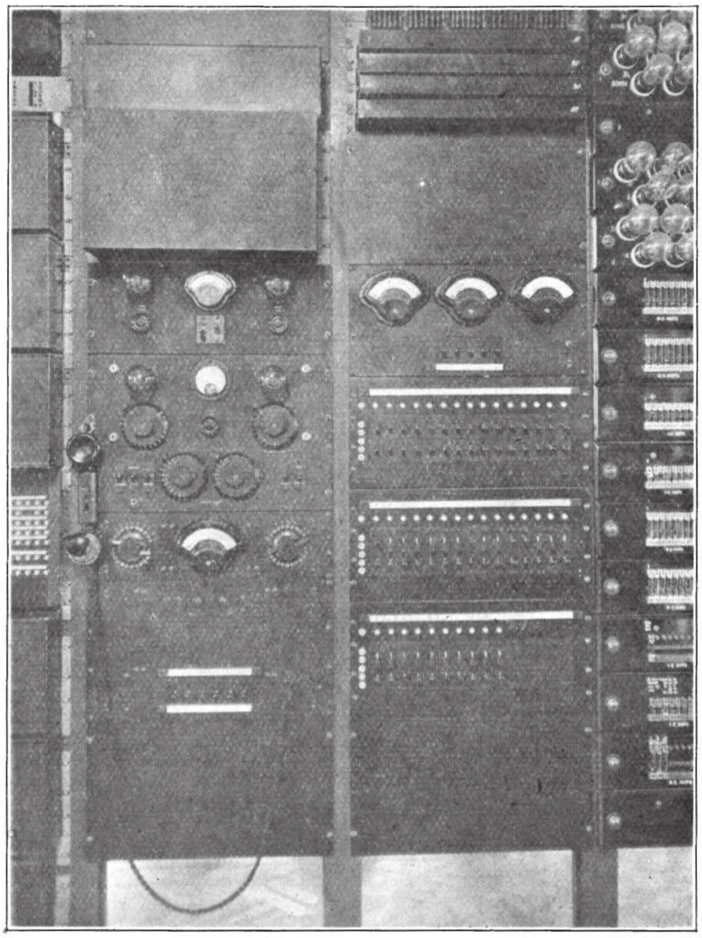


FIG. **15**.—TEST BAYS.

Each Repeater Rack, Figs. **13** and **14**, includes in addition to 7 (in some cases 8) Repeater Bays, each carrying 5 Repeaters, Test Bays (Fig. **15**) and a Fuse Bay (Fig. **16**). The Test Bays include on the left the Repeater Gain Test Set, the Filament Current Control, and the Telephone Panels, and on the right the Battery Supply Bay (Fig. **17**).

The Repeater Gain Test equipment consists of a single frequency valve oscillator, a rectifier-amplifier measuring circuit and an adjustable artificial cable. By means of this equipment the Repeater attendant can make a rapid check test of the amplification of any repeater under his charge. The circuit arrangement is shown in Figs. **18** and **19**.

The Filament Current Control apparatus is used in setting up a repeater for service, and when valves require to be renewed or changed. On the repeater rack the filament current is controlled by a series of small fixed resistance spoools, seen in Figs. **6** and **16**. The values of these resistances are determined by means of the rheostat and ammeter of the Filament Current Control circuit. As the average life of these valves exceeds one year's continuous running (in fact some of them have reached 15,000 hours life) the changing of resistance spools is an infrequent operation.

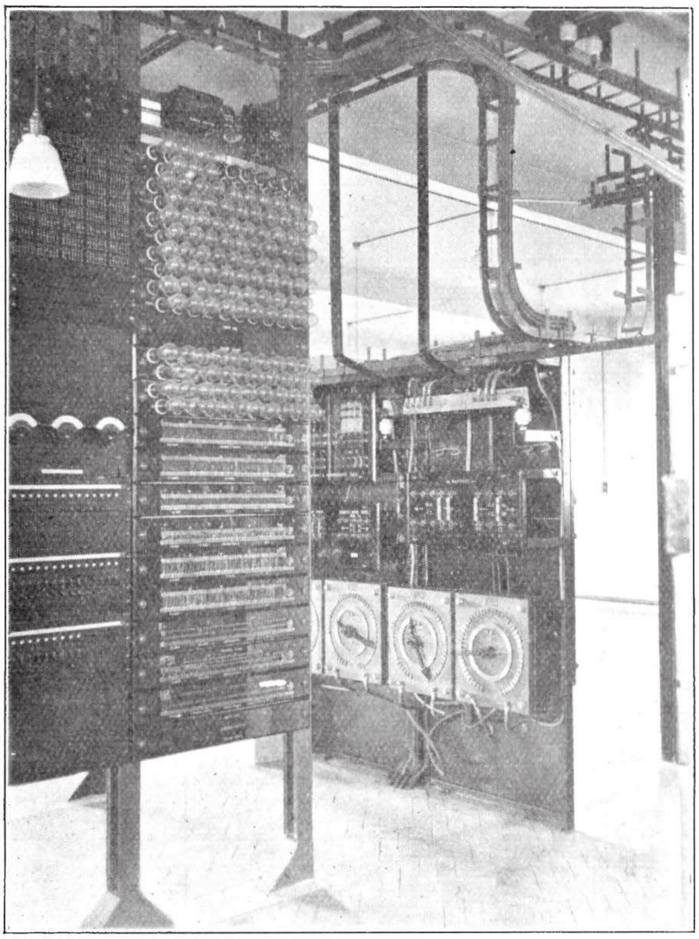


FIG. **16**.—FUSE BAY AND NEAR VIEW OF VOLTAGE CONTROL BOARD.

The Telephone Panel provides means for speaking and monitoring on any repeatered circuit in the rack. The valve circuits of each repeater are led through the Battery Supply Bay and the arrangements of keys and meters provides means for measuring the filament current and the plate current of any repeater in the rack.

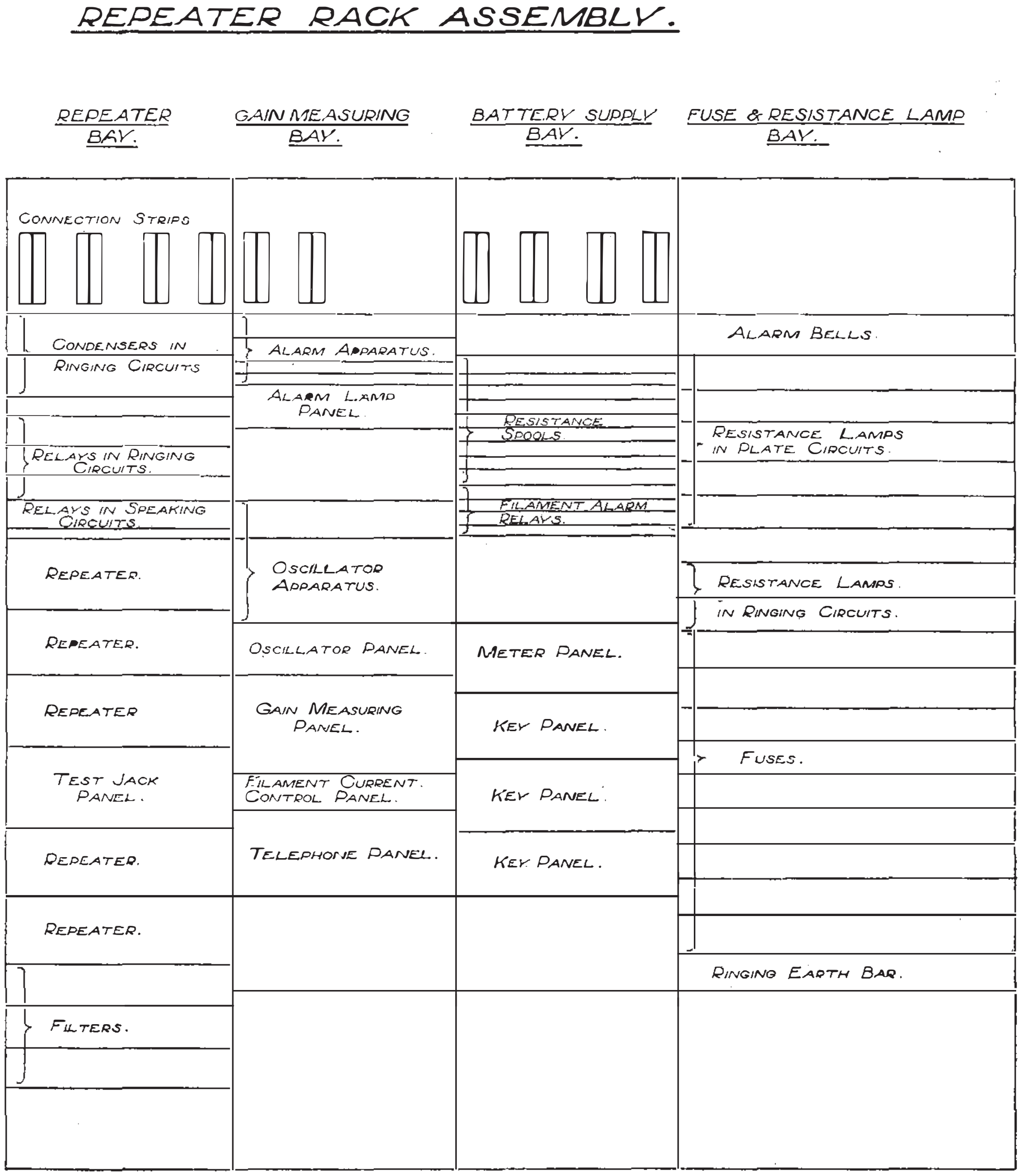


FIG. **17**.—REPEATER RACK ASSEMBLY.

The purposes of the Fuse Panel will be seen by reference to the general circuit diagram, Fig. **6**.

It will be seen in Fig. **8** that each Repeater Bay carries a Test Jack Panel, which gives ready access to any part of a repeater circuit and also provides means for crossing out a faulty repeater and extending it to the main Test Desk for special attention.

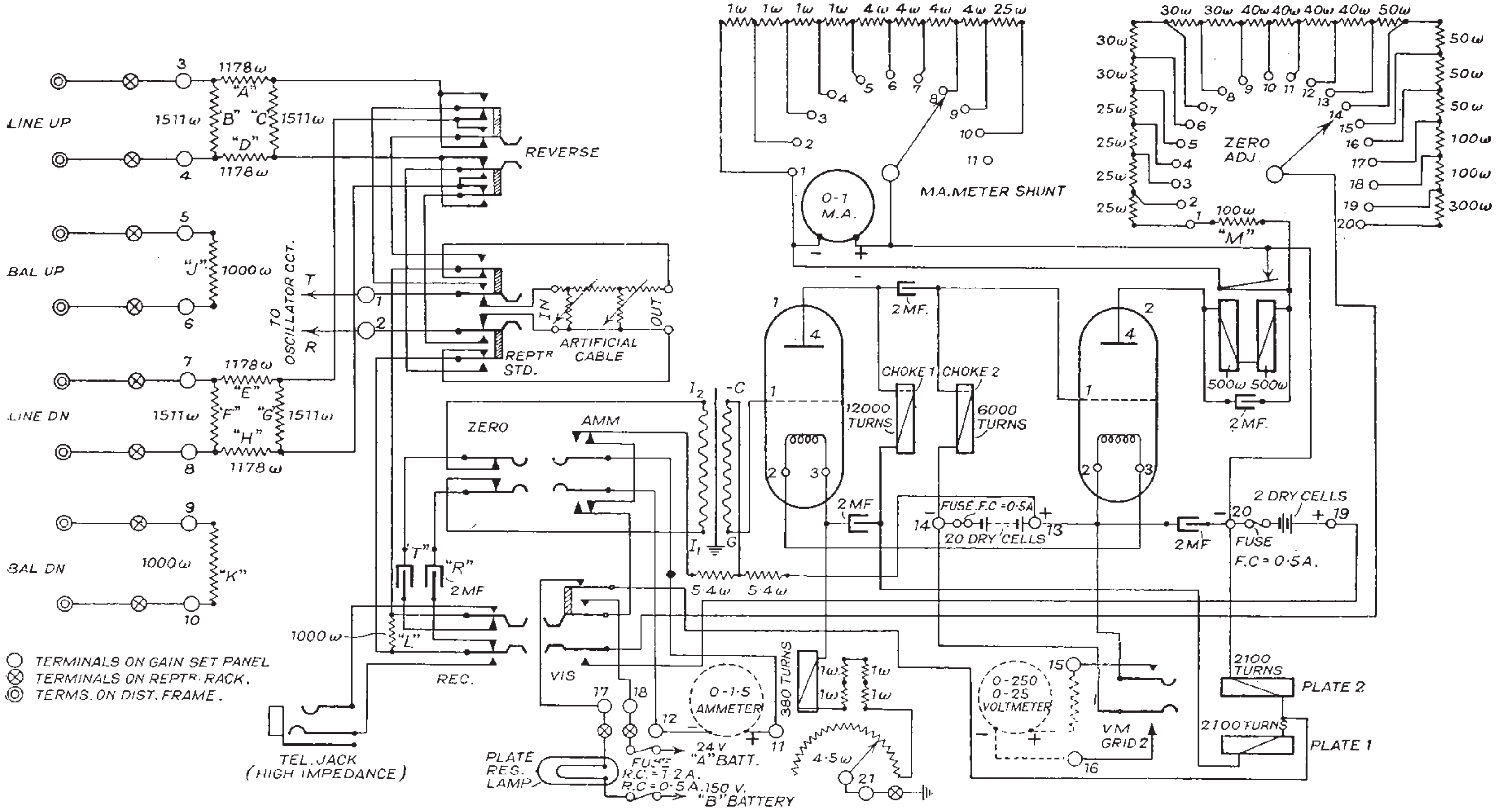


FIG. 18.—GAIN SET CIRCUIT (RECEIVER AND VISUAL) RACK TYPE FOR TELEPHONE REPEATER STATIONS.

The signalling repeater, which relays the 16-cycle currents used normally on trunk lines, is an arrangement of relays which conforms to telephone exchange practice. The various components of the repeater are shown in the general wiring diagram and as their respective functions will be clearly seen no special description is necessary. It may be mentioned here, however, that the necessity for relaying the 16-cycle signalling currents of a trunk line constitutes one of the limiting conditions to the number of 2-wire repeaters which can be operated in a " through " line. The fact that the speech current circuit must be passed through the contacts of the cut-off relays introduces a variable and, at times, troublesome feature in the impedance of the line circuit, resulting in the risk of fleeting " out-of-balance " conditions. Experience has proved that where it is necessary to exceed 3 repeaters in a 2-wire through circuit, it is desirable to transform the 16-cycle signalling current at the terminal stations into a higher frequency, preferably 500 cycles, at speech current amplitude which can be dealt with at the repeaters without mechanical relays. Under service traffic conditions, however, a higher overall transmission efficiency than is possible with 2-wire working is generally demanded on long circuits exceeding 3 repeater sections, that is to say, 150 to 180 miles, and 4-wire working is resorted to.

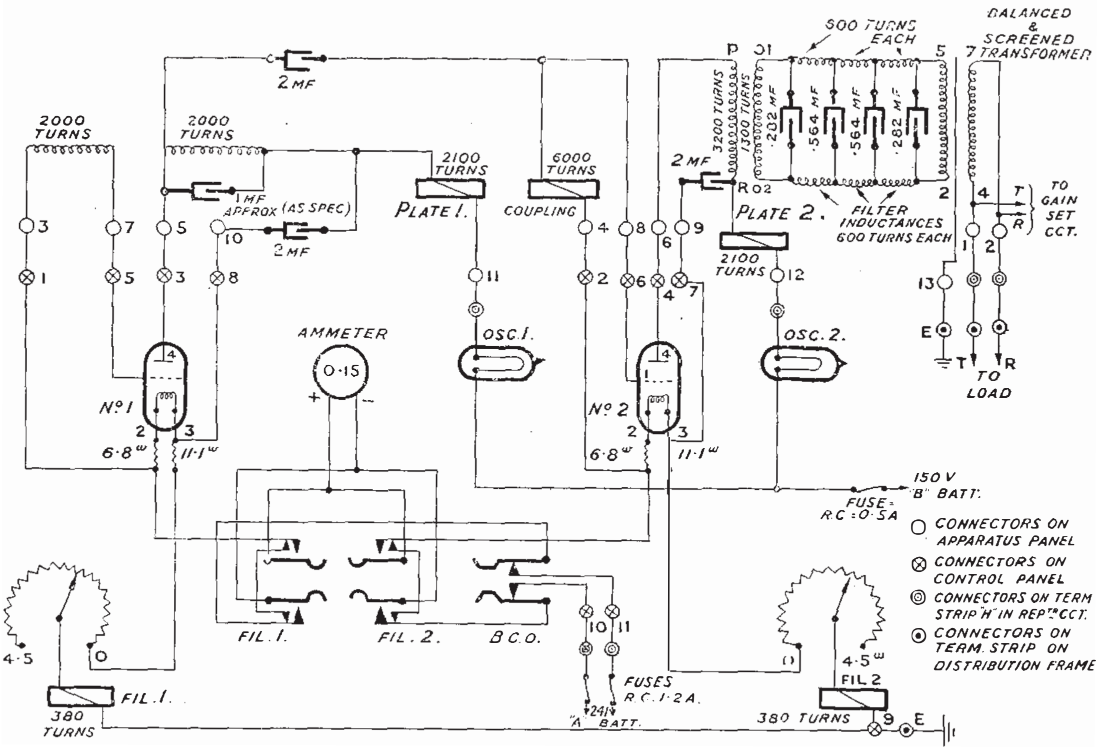


FIG. 19.—CIRCUIT OF FIXED FREQUENCY OSCILLATOR.

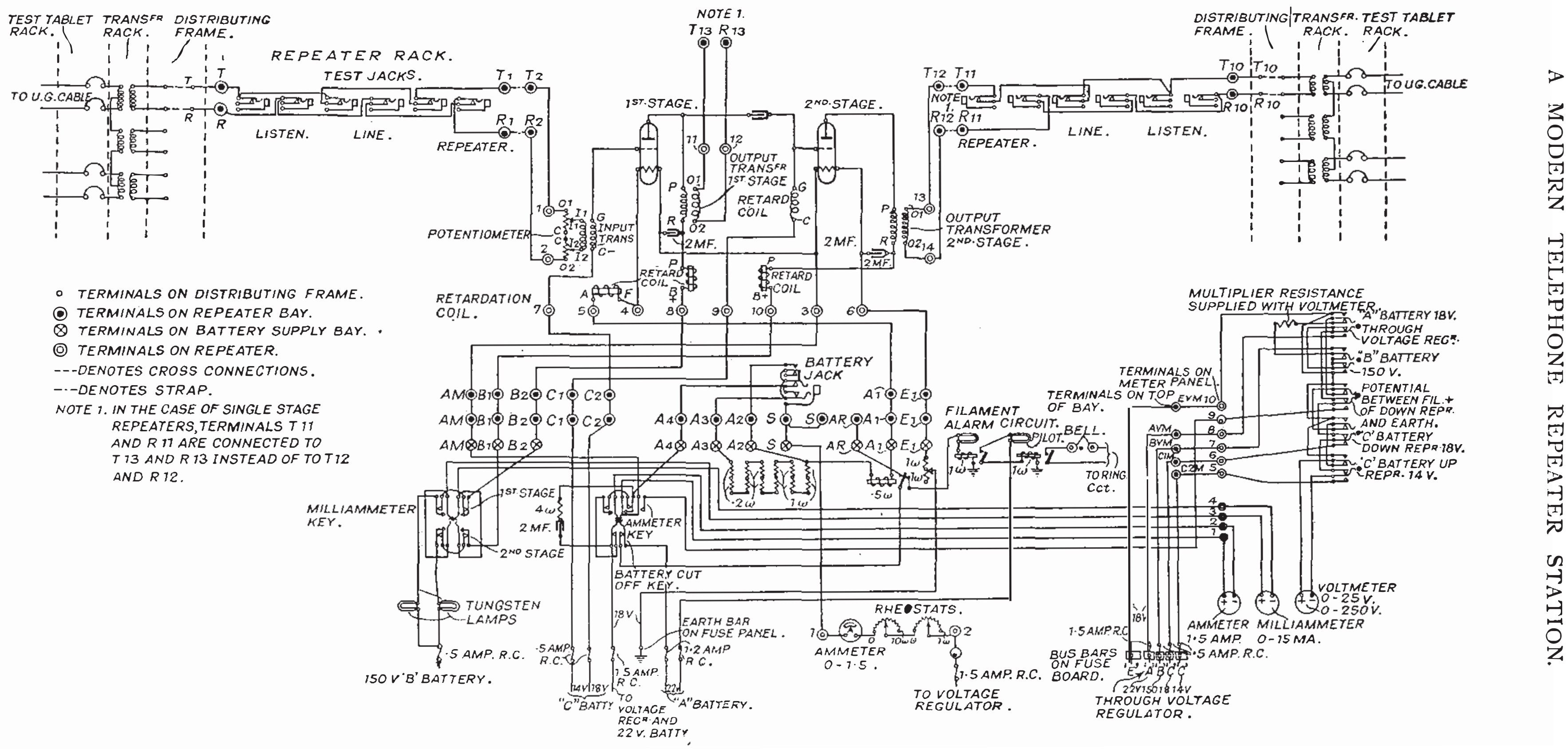


FIG. 20.—TELEPHONIC REPEATER STATIONS—FOUR-WIRE REPEATER CIRCUIT WITH TELEPHONIC REPEATER NO. 11. MARLBOROUGH AND TAPLOW.

4-Wire Working.—The station cabling arrangements are the same as for 2-wire working up to the Transformer Rack, but from this point the cabling makes provision for efficient separation of the " goes " and " returns " of 4-wire circuits. Fig. **20** illustrates in schematic form the wiring of one side of a 4-wire circuit in the Station. The other side of the circuit is precisely similar. It will be seen that the controls of the valve circuits are arranged in the same manner as for 2-wire repeaters.

Fig. **21** is a photographic illustration of a 4-wire repeater unit.

As indicated above, the 500-cycle signalling system used for 4-wire working requires no relays at intermediate repeater stations and in this respect the wiring of 4-wire circuits is simpler than that of 2-wire circuits. As a matter of interest a schematic diagram of the signalling circuit for terminal stations on 4-wire circuits is given in Fig. **22**.

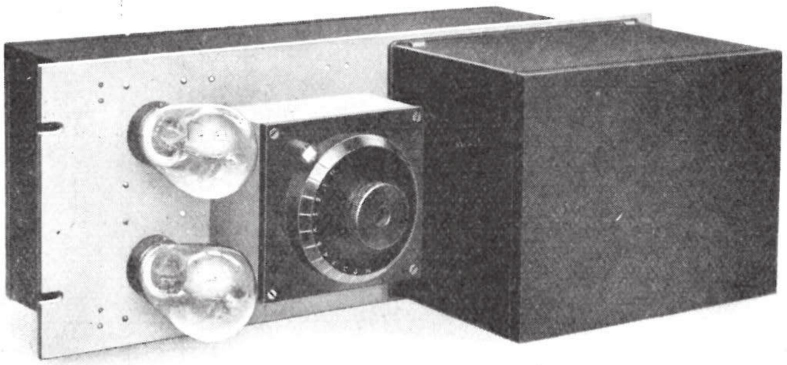


FIG. **21**.—FOUR-WIRE REPEATER.

The Test Desk equipment of a modern Repeater Station comprises a small laboratory of high grade testing instruments. The equipment is in two sections, namely, the Repeater Test Desk and the Cable Test Desk (Fig. **23**).

The former is divided into 5 panels as indicated in the sketch shown in Figs. **24** and **25**.

The telephone and jack panel provides means for speaking to any point in the station or along the line, accommodation for the standard telephone is also provided in this portion of the Desk. The transmission measurement apparatus and the condenser associated with the filter in the oscillator circuit are in the second panel. The variable frequency oscillator, which covers a range from 200 to 2,500 cycles per second with an average output of 25 milliamperes through 1000 ohms, is in the third panel. The oscillator supplies energy for the Transmission Measurement Set and to the alternating current bridge in the fourth panel. The

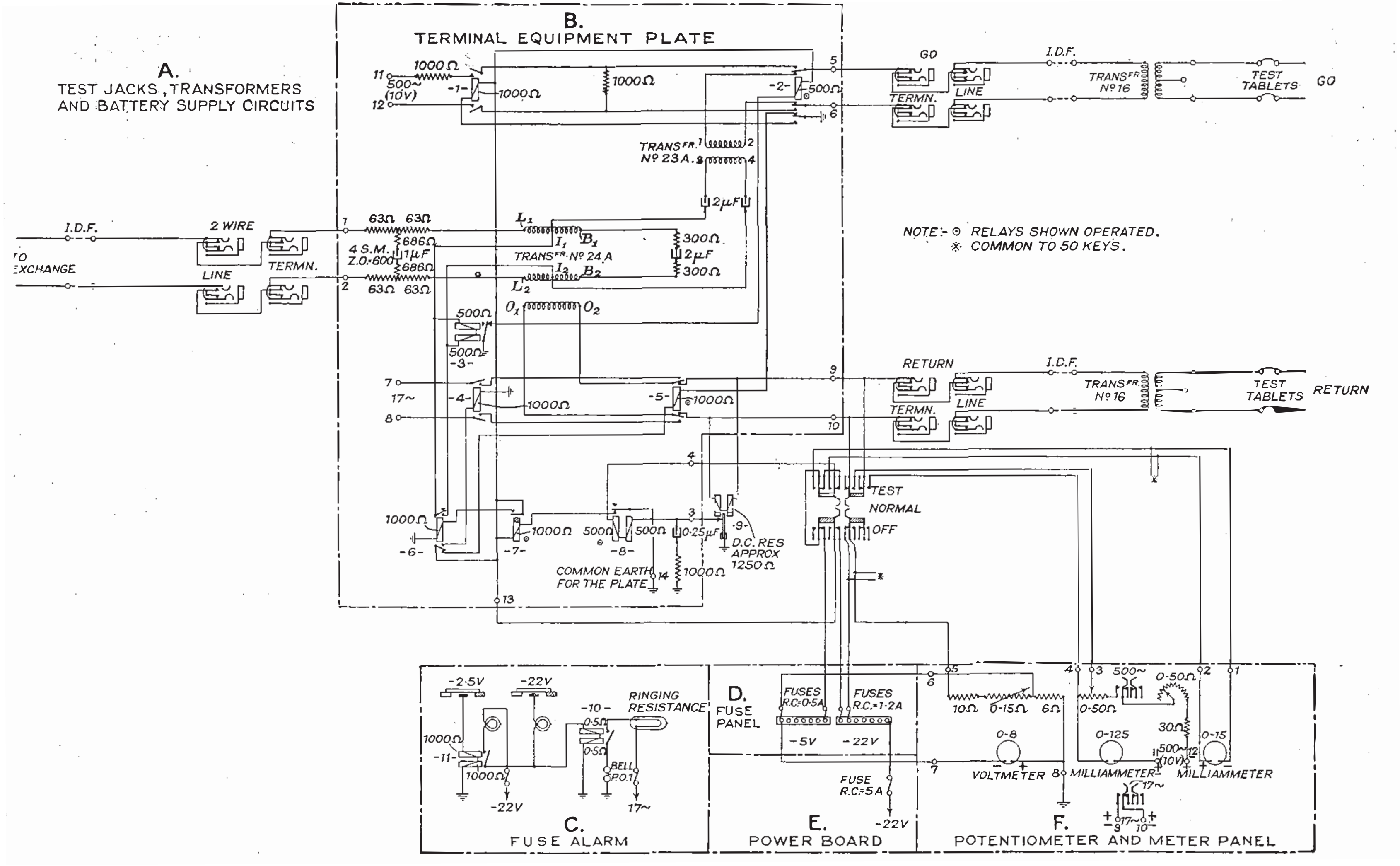


Fig. 22.—Diagram of Connections of Terminal Equipment for Four-Wire Repeater Circuits.

switches in the alternating current bridge panel connect the apparatus for calibration of the oscillator or measuring the impedance of circuits with positive or negative angles. Leads to various positions in the repeater station from which impedance measurements are required terminate on the fifth panel.

The transmission measurement apparatus comprises the variable frequency oscillator already referred to and means for measuring the current sent out, together with a valve amplifying and detecting equipment for measuring the received current. In addition an artificial cable is provided for comparison purposes.

In making a transmission measurement a current of known value (usually 3 MA) and of the desired frequency is sent into one end of the circuit and the reading of the milliameter in the receiving apparatus connected to the other end of the circuit is noted. An artificial cable is then substituted for the circuit under test and the cable is adjusted until the same reading as that recorded on the first test is obtained. The reading on the artificial cable will then indicate the transmission efficiency of the circuit under test.

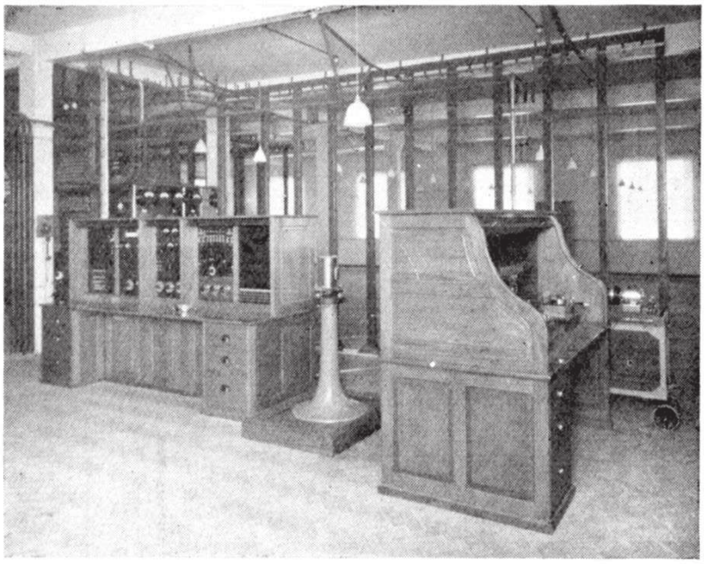


FIG. 23.—REPEATER AND CABLE TEST DESKS.

If the two ends of the circuit are not in the same station, one station will send out the standard current (3 MA) and the other station will note the reading obtained on the milliameter of his receiving apparatus. The latter station will then substitute his own oscillator and an artificial cable for the distant station's oscillator and the line and will adjust his artificial cable until the reading obtained on the test of the line is reproduced.

The artificial cable reading will then, as before, indicate the transmission efficiency of the circuit.

The Cable Test Desk, Fig. **26**, provides facilities for insulation measurements, both inside the station and outside on the " line," and means for localisation of faults.

The Sullivan Reflecting Galvanometer, seen behind the desk in Fig. **23**, is carried on a heavy cast-iron base fixed to a large stone slab. A 3-inch pad of " Sorbo " is placed under the galvanometer, which throws its beam through a window in the back of the desk. The fact that this galvanometer can be used when either of the engine generator sets is running in the power room below speaks for the design of the buildings and in no less degree for the quality of British prime movers.

Standard Telephone.	Galvanometer Panel.	Meter Panel.	Switching Panel for A.C. Bridge.	Spare.
	Transmission Measuring Set.	Oscillator Panel.	Rheostat for A.C. Bridge.	
Telephone & Jack Panel.	Filter Tuning Condenser.	Anode Tuning Condenser for Oscillator Cct.	Condenser for A.C. Bridge.	Leads to Testing Points.

FIG. **24**.—ARRANGEMENT OF EQUIPMENT ON REPEATER TEST DESK.

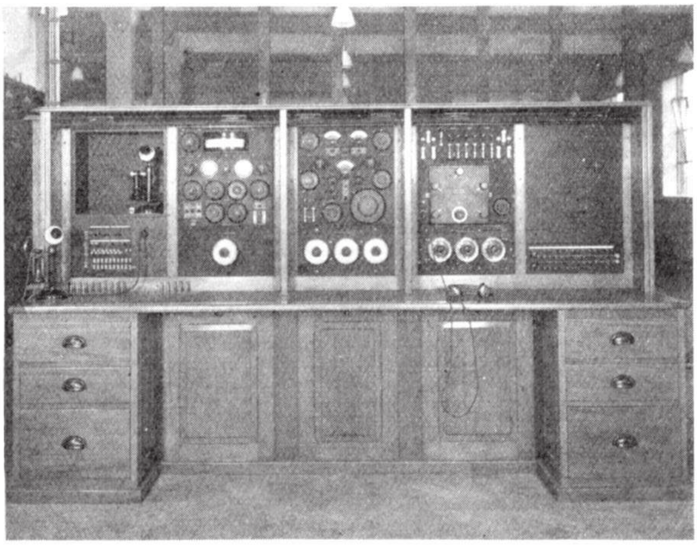


FIG. **25**.—REPEATER TEST DESK. CLOSE UP.

The Cable Desk equipment includes also a motor-driven megger of special design (seen mounted on a perambulator carriage in the picture), which supplies current at 500-volts for insulation measurements.

A portable 250-volt motor-driven bridge megger is also supplied as part of the normal equipment of a Repeater Station.

The Power Plant of a large Telephone Repeater Station corresponds in the main to the power plant of a large modern Telephone Exchange. The fact that the former in many cases is located in an isolated position involves some addition to the normal requirements of a large Exchange, *e.g.*, prime movers, lighting and, in some cases, pumping. It will probably be sufficient, therefore, to describe in detail only those features peculiar to a Repeater Station.

When the first group of stations on the main cable network was designed the standard thermionic valve used by the Post Office for repeater service required a supply of about 6 watts in its filament circuit, approximately 1.2 amperes at 5 volts. It was found convenient and economical to run the filaments of the two valves of a 2-wire repeater or the 2 valves of one side of a 4-wire repeater in series. An allowance for a drop of 3 to 4 volts was necessary for filament control resistances, filament alarm relays, etc. Voltage drop in cabling brought the total up to 15 volts and an 8-cell filament battery was indicated. The desirability of using standard types of telephone ringing relays designed primarily for 22-volt C.B. Exchanges, and the probability of being able to run 4 valves in series at a later date led finally to the provision of 11 cells in the A battery. The initial repeater room layout

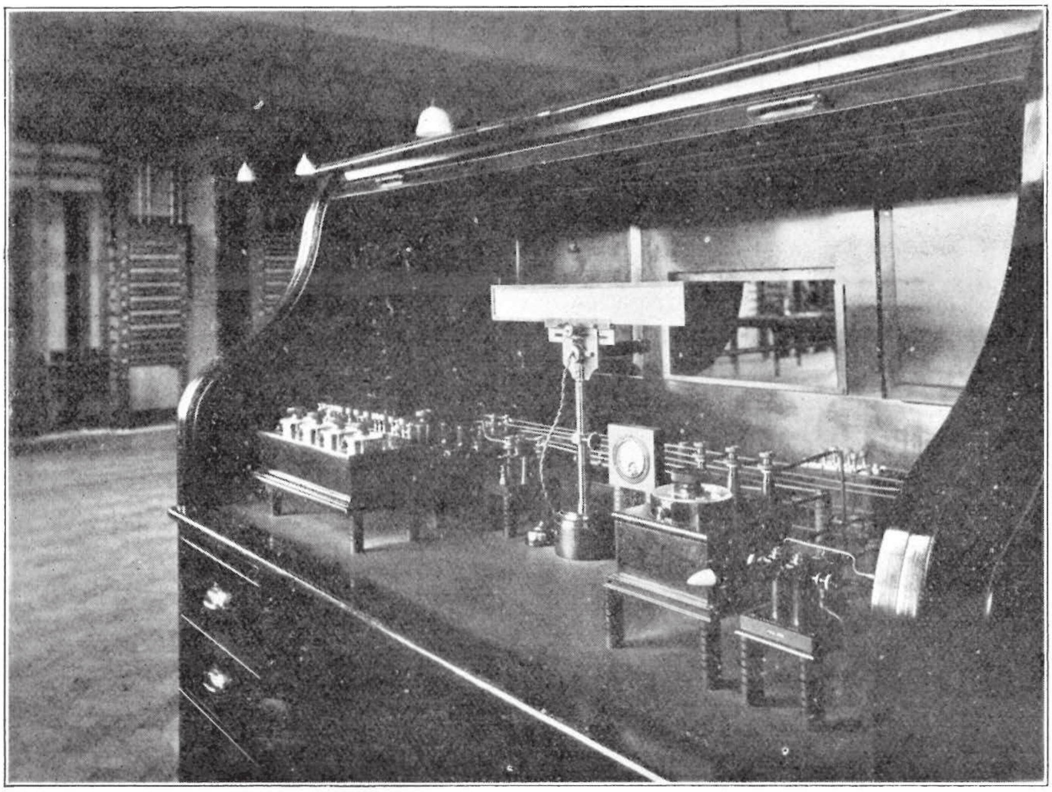


FIG. 26.—CABLE TEST DESK.

provided for a maximum of 520 repeaters; the ultimate for the route was taken as 1000 repeaters and the average daily run for a trunk circuit on a main cable route is 13 hours. It will not be necessary, therefore, to detail the figuring which led to the provision of filament battery cells having a maximum tank capacity for 10,000 ampere hours, and an initial plated capacity for 5,000 ampere hours, nor to explain how a charging generator rated at 1000 amperes 22-30 volts is arrived at. The filament battery is known in the station as the " A " battery. The " A " battery is provided in duplicate.

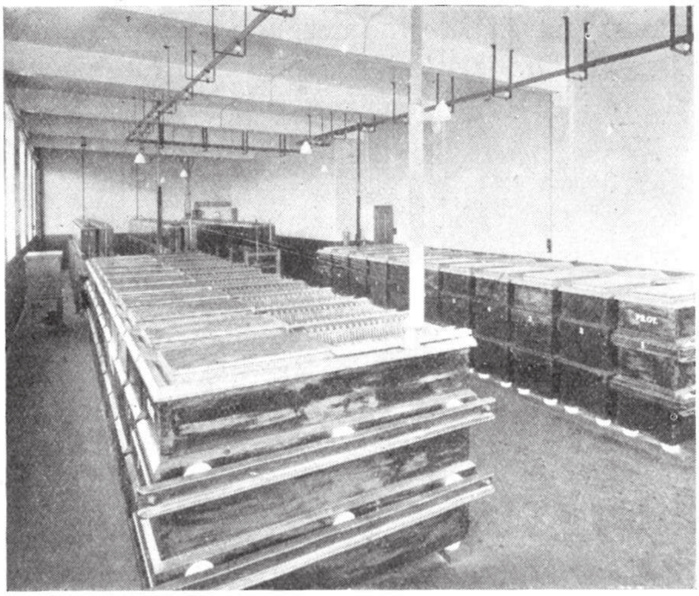


FIG. 32.—BATTERY ROOM.

The " B " battery supplies the valve plate circuits, auxiliary motors on pumps, air compressors, ringing machines and vacuum cleaners, and the lighting circuits. The valve plate circuits require approximately 0.010 amperes at 150 volts. Provision for motor and lighting circuits indicated a battery with a maximum plated capacity of 300 ampere hours. This battery is provided in triplicate, one on " charge " and two on " discharge," as the running of motor and lighting circuits in parallel with the valve plate circuits introduces objectionable disturbance effects in the latter.

The " C " battery is a 10-cell 20 ampere hour battery used for " priming " the grids of the valves.

The problem of prime movers for Telephone Repeater Stations presented some interesting difficulties when the first stations were designed.

Considerations of economy in building costs and maintenance staff charges indicated a building of two floors with all the generating plant and batteries on the ground floor. The requirements of the valve filament circuits pointed to a layout which involved the shortest possible cable run from the battery to the repeater racks *via* the repeater room voltage control board. The same arguments applied to the distance between charging generators and batteries. It was obviously not a case for steam engines. Producer gas engines were ruled out, principally on account of possible difficulties with fuel supplies in certain emergency conditions. Petrol engines were not viewed with favour. The fact that oil fuel storage is a comparatively easy problem and that a supply of fuel oil could be guaranteed by the authorities even in periods of emergency led to the decision to provide oil engines as prime movers. The choice lay between engines running on paraffin and the lighter petroleum products and those running on the heavier petroleums. The engineers of several of the leading oil-engine firms were consulted and this opportunity may be taken to put on record the valuable assistance afforded in solving the repeater station engine problem by the engineers of Messrs. Crossley Brothers, Manchester and London, Messrs. Ruston & Hornsby, Lincoln and London, and Messrs. Vickers, Petter, Ipswich and London.

At the time the early consultations took place, 1920-21, the most economical combinations (from the capital cost point of view only) of engine and generators were the 4-stroke high speed vertical paraffin engine and the 2-stroke medium speed vertical engine of so-called semi-Diesel type running on light residual oil of s.g. 850 or thereabouts, the generators 22-30 volt and 150-200 volts being coupled direct in tandem to the engine shaft in both cases.

Taking into account the requirements to be met if the engine room were to be located beneath the repeater room, neither of those combinations was considered to be free from objection in respect of noise and vibration. Undue noise meant interference with testing and monitoring in the repeater room, and vibration would cause rapid destruction of valve filaments and in certain conditions interference with circuit working. In addition there were objections to the storage of paraffin, and the 2-stroke vertical engine had, at that time at any rate, certain inherent defects that could cause much maintenance trouble. Both types, moreover, required rather generous head-room provision.

The alternative to the high speed vertical engine was the 4-stroke horizontal slow speed engine; many types of horizontal engine were on the market, and at this time development of the modern heavy oil engine which will start from cold was well advanced and several specimens of this type were available for inspection. The first cost of this type of engine was higher than that of the vertical types; it required a much larger floor space and on account of its relatively slow speed the generators, especially for 23-30 volts supply, were necessarily heavy and costly. On the other hand, fuel consumption was low, and a very low grade of fuel could be used if necessary.

The floor space requirement was not a serious one in the circumstances of a two-storey Repeater Station, as the floor area of the Repeater Room is the determining factor and in a large station is always greater than the space needed for generating plant.

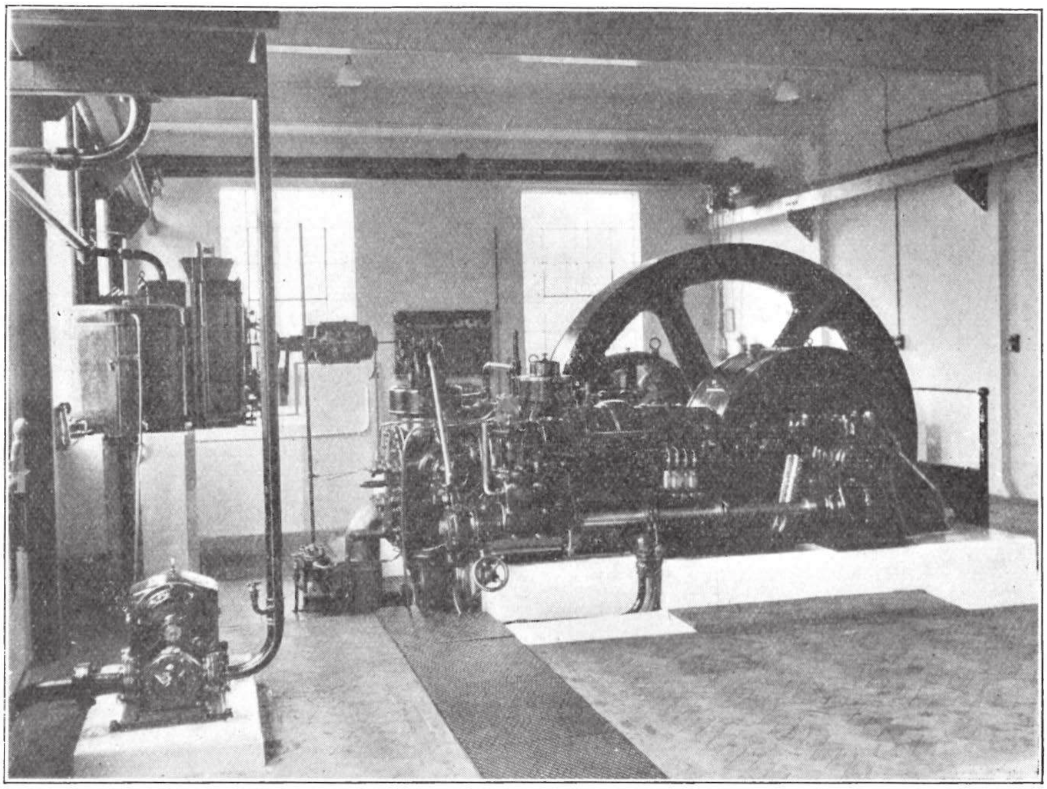


FIG. 27.—MESSRS. RUSTON & HORNSBY COLD STARTING ENGINE MARK II H.

After careful study of the whole matter a decision was reached to adopt the horizontal 4-stroke engine and a general specification embodying the following requirements was drawn up:—

(*a*) Engine to start from all cold without the aid of blow lamp or other heating device.
(*b*) Cyclic speed variation not to exceed 1.25%.
(*c*) Engine to run normally on the fuel sold as Diesel oil, but able to run in emergency on Admiralty furnace oil or on paraffin.
(*d*) Efficient silencing arrangements.
(*e*) Engine to be able to maintain a continuous output from the generators of 40 K.W.

Quotations were invited from several firms and, after rejecting those which did not fully comply with the requirements indicated, the final decision was given in favour of the Ruston & Hornsby engine.

The engine illustrated in Fig. **27** was made and installed by this firm and is the standard type for the first series of large repeater stations. Its nominal output is 76 B.H.P.

In this type of engine the fuel is injected into the combustion space by a pump, no compressed air being needed for this purpose. The pressure in the cylinder is high enough to ensure instantaneous ignition and combustion. The inlet and exhaust valves are operated by eccentric gear, a feature which makes for smooth and quiet running.

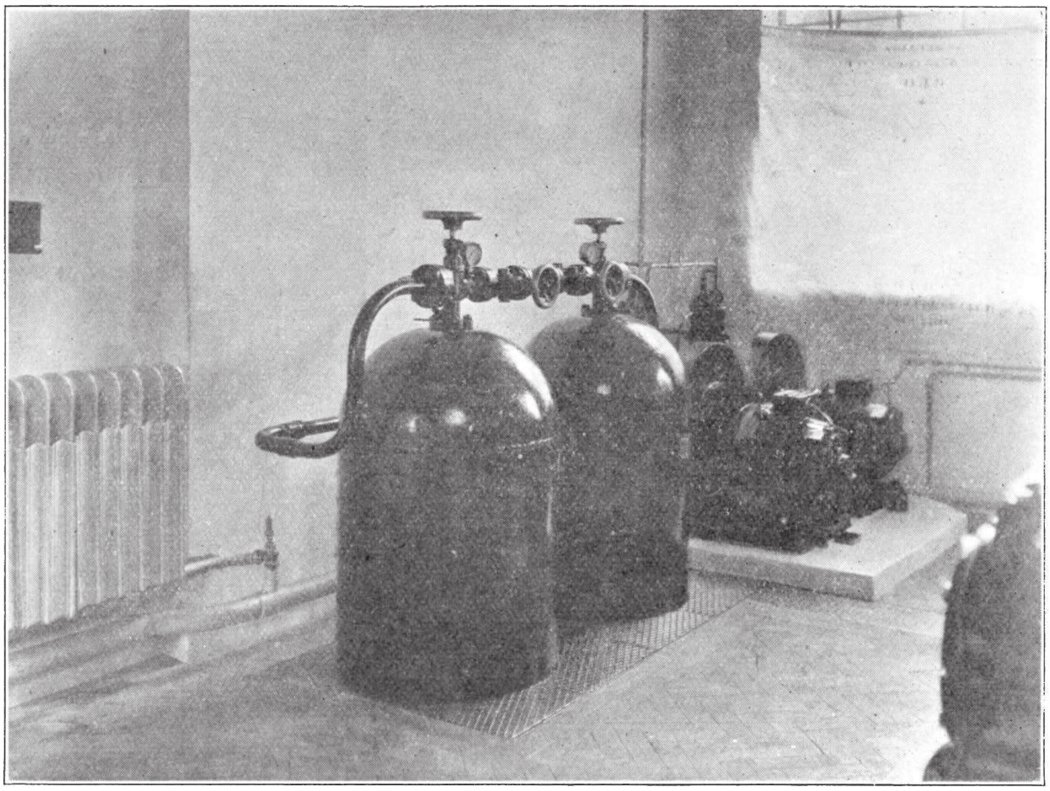


Fig. **28**.—Air Receiver and Compressors.

Motion is imparted to the fuel pump plunger by a cam on the lay shaft and the whole of the gear is enclosed in oil baths. Governing is effected by by-passing a greater or less proportion of the oil pumped back to the service oil tank. The fuel oil leaving the pump passes to the atomiser arranged in the cylinder head. The atomiser cannot deliver a charge until the pressure of the oil from the pump is sufficient to overcome the resistance of a spring-loaded needle valve. The oil enters the combustion space in the form of a very finely divided spray so that it is instantly ignited and effectively consumed.

The engine is started by compressed air which is admitted by a mechanically controlled valve.

The compressed air reservoirs (normally filled up to a pressure of 300 lbs. per spare inch) are seen with their motor-driven compressors in Fig. 28. The motor circuits are arranged so that they may be connected either to the 150-volt battery circuit or direct to the 200-volt generators.

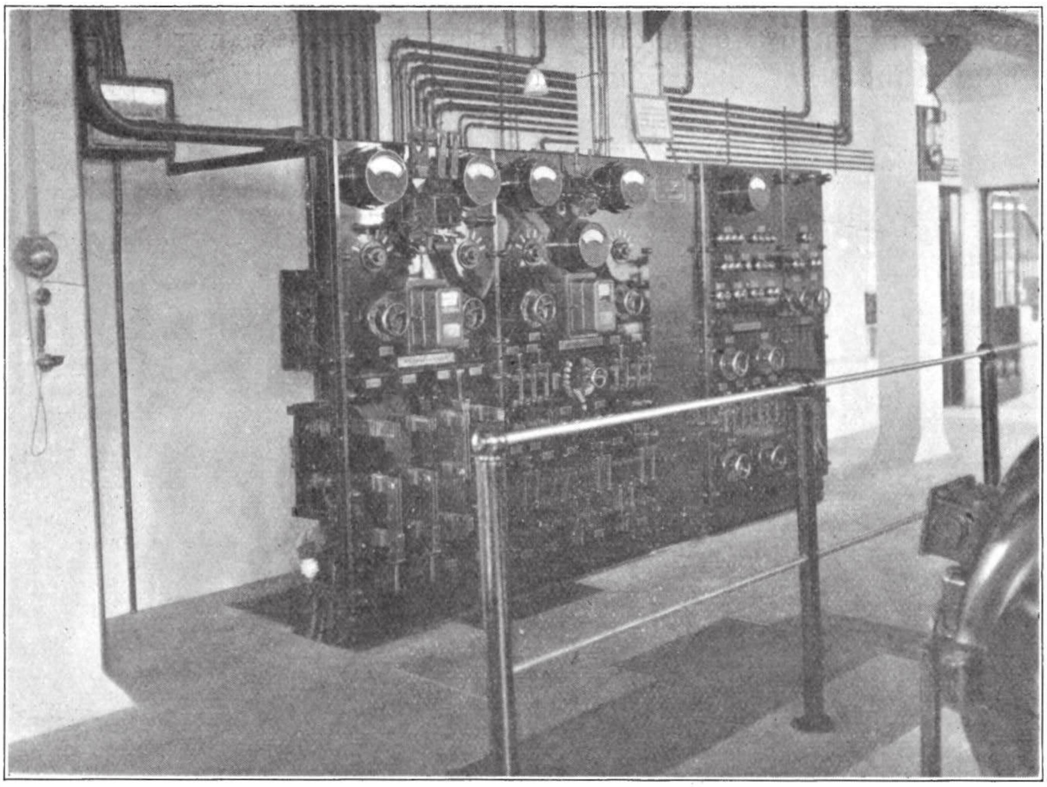


FIG. 29.—POWER BOARD.

Even in frosty weather these engines start from cold, after 5 or 6 revolutions under compressed air, without hesitation on any fuel oil which is not too viscous at low temperature. Provision has been made in the main oil fuel tanks for connection with the central hot water heating system, so that in the event of necessity to use a low grade viscous fuel in very cold weather the temperature of the fuel may be increased. Alternative provision has been made so that the engine may be started on a small supply of light fuel oil until the heavier oil becomes warmed by the heat of the exhaust.

An important feature of this type of engine is the very low fuel consumption at light loads. The normal fuel consumption obtained under every day working conditions are:—

Full Load.	*¾ Load.*	*½ Load.*	
0.44	0.45	0.53	lbs. per B.H.P. per hour.

Provision is made for the storage in two tanks, placed in an underground concrete chamber of 5,000 gallons of fuel oil.

The array of large tanks for cooling water, usually in the past associated with engines of this size and type has been dispensed with in favour of the Heenan Cooling System.

The cooler seen in Fig. **27** consists essentially of a cast-iron casing in which two metallic wool screens are fitted vertically one behind the other, the cooling effect being obtained by distributing the hot water over these screens, and at the same time forcing a current of air through them by means of a propeller type fan bolted to the front of the casing. The hot water from the engine jackets is delivered to a trough formed in the top of the casing, and after passing through a detachable strainer is evenly distributed over the screens through perforated brass plates fitted in the bottom of the trough. The cooled water collects in the base of the cooler from whence it is re-circulated to the jackets by means of a small positive-gear type pump bolted direct to the casing.

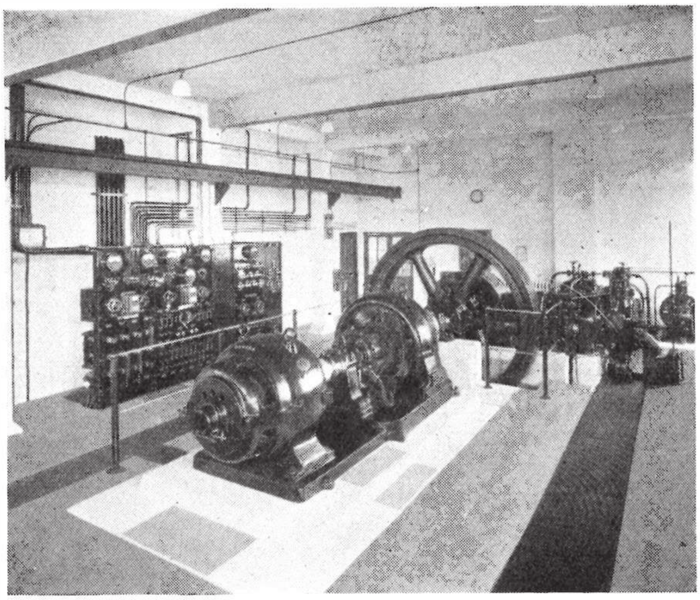


Fig. **30**.—General View of Power Room.

The air after passing through the screens is discharged

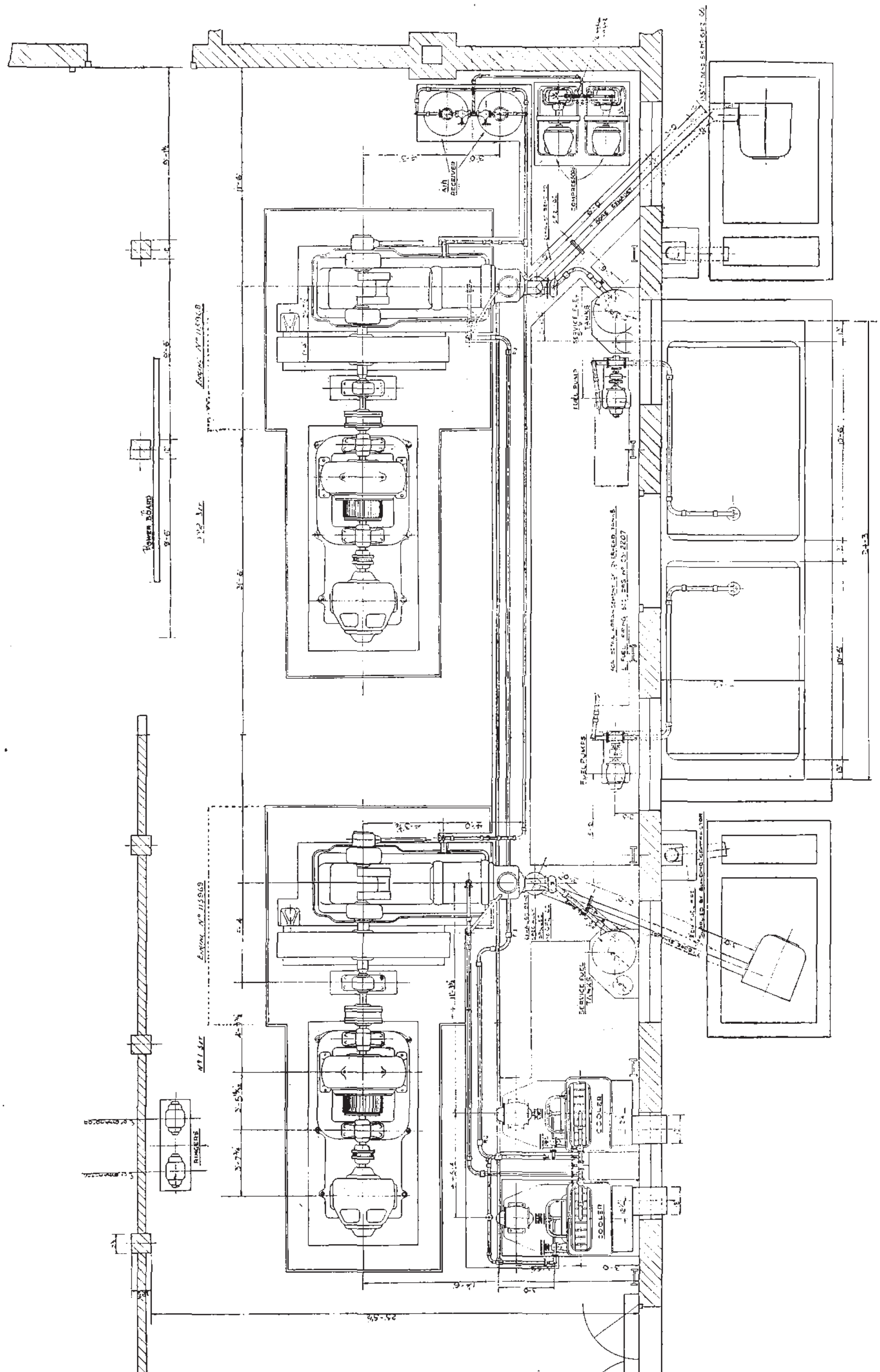


FIG. 31.—LAY-OUT OF ENGINE ROOM.

through a duct to the outside of the building. To prevent drops of water being carried away by the current of air, an eliminator consisting of a series of vertical iron blades mounted in a separate framework is fixed immediately inside the cooler outlet. The eliminator is removable so that access may be gained to the make-up ball-float valve and to the screens.

The fan is driven by a direct-coupled motor and the pump is belt-driven by the same motor. The motor is connected to the 150-200 volt generator, no starting switch is provided, and the motor starts and stops automatically with the engine.

A "Monitor Valve Safety Device" is provided in the cooling water supply of each engine as an additional precaution against failure of the cooling water supply. The monitor valve controls three electrical contacts. While the engine is running and the water-cooling system is in order the monitor valve closes the circuit of an electric lamp connected to the generators and placed in a conspicuous position. Should the cooling water supply fail the valve opens the lamp circuit and closes that of an electric bell, thus giving a visible and audible indication of the failure.

The question has been asked, and may be asked again: how is the engine started up for the first time after installation as there is no battery supply available for the compressed air starter motor? The answer is that one of the air reservoirs (they are in duplicate and are interconnected) has to be sent to the station already filled, although it is said that a reservoir could be filled by a manual pump.

The Main Switchboard controlling the generator, motor and battery circuits is illustrated in Fig. **29** and requires no detailed description. It carries the usual switchgear, fuses, circuit-breakers and alarms.

Fig. **30** is a general view of the Power Room, and Fig. **31** shows the layout.

The A battery supply to the Valve circuits is led from the Main Switchboard to the Repeater Room.

Voltage Control Board. Figs. **14** and **16**.

The 50-stop regulating switches with their associated resistance and alarm contact voltmeters give the station supervisor a means of holding the voltage of the valve filament circuit within very close limits.

In practice a limit of ± 0.4 volt is worked to.

The General Electric Co., Ltd., London, were the contractors for the whole of the equipment of these stations with Messrs. Ruston & Hornsby, Ltd., and the Premier Accumulator Co. as subcontractors for the engines and batteries respectively.

A.B.H.

GROWTH AND FINANCE OF THE POST OFFICE TELEPHONE SERVICE.

By W. J. Medlyn, M.I.E.E.

Sir W. Mitchell-Thomson, the Postmaster-General, in introducing the Post Office Estimates in the House of Commons on the 20th July, 1925, made some very interesting observations on the growth and finance of the telephone service. He said that it was the general policy of the Government that the telephone service should pay its way, and, since the introduction of the new tariff to correspond with the increased working costs due to inflation of values, in 1922, this policy had been successfully carried out. At the same time a pledge which had been given that, when circumstances permitted, rates should be reduced, had already been fulfilled, and it was estimated that the concessions made in the last three years represented a sacrifice of revenue of about £3,000,000, of which the telephone users were reaping the benefits. The net increase in the number of telephones last year was 115,308, or 10%, bringing the total up to 1,273,800 stations; this had beaten all previous records. Special attention was directed to the fact that the finance of the telephone service depended very largely on the call revenue, and a more extensive use of the telephone would tend not only to a better service, but to a further reduction of charges in the future. One extra call per day originated from each telephone would represent nearly £2,000,000 additional revenue. Notwithstanding, and no doubt to some extent in consequence of, the reduction in rates during the past three years the telephone revenue was steadily rising, and, in round figures, it was estimated that the receipts, amounting to £14,500,000 in 1923-24, would increase to something over £16,200,000 next year.

In referring to the magnitude of the Post Office work the Postmaster-General said the nearest figure he could get to represent the total value of transactions backwards and forwards with the public was £785,000,000. In such a business it was inevitable that mistakes should occur and things go wrong. He asked the public to keep a sense of proportion in these matters, and he assured them that he recognised the value of criticism as a help towards greater efficiency.

In opening the discussion, Mr. Hartshorn, who was Postmaster-General in the late Government, said that he went to the Post Office with a bias against it, but left it with the conviction that it was the most wonderful piece of business organisation that had ever been constructed in this world. He did not at all agree with the adverse criticisms sometimes urged against the Post Office on the ground that its staff was inefficient from a business point of view. From the Permanent Secretary down through all the branches he found, as the heads of departments, men and women of outstanding ability. He regretted that the Post Office seemed to be regarded in this country as a sort of secondary department. The present Postmaster-General was the sixth occupant of that office in two years. He thought there was no more important Department in the State. Considering the magnitude of the business, it was surprising that there were so few complaints.

The report was well received by the House, and the Estimates were passed.

The present position of the telephone service is a gratifying change from the dark days of 1920, when, during a period of soaring prices, a large section of the public demanded from the Post Office the miracle of providing improved facilities at pre-war rates. Even in these days when a pre-war pennyworth of private enterprise costs the purchaser a penny three farthings, or more, there are many people who feel aggrieved because they cannot yet revert to the penny post, thus showing a lack of appreciation of the good bargain they are actually getting. The partial remedy for such a grievance is to get the telephone installed, when the subscriber can not only send out his local communications for the much desired fee of a penny, but can receive his correspondent's reply as well, without further charge.

The overtaking of arrears of work resulting from the unavoidable conditions arising out of the war (so that new lines can now be promptly joined up), and the improvement in telephone finance, as well as improvement in facilities and in quality of service, is an achievement of which the Post Office staff may well be proud. These results have been accomplished not only by the good management of the higher officers of the Post Office, but by the close co-operation and team work between the different departments and the zealous enterprise of the rank and file of the staff. It is also a fortunate thing for the Post Office, as well as for the wider interests of the community, that we have a Postmaster-General who is not only convinced of the success and future possibilities of the telephone industry in this country, but who is able to assemble his facts in such a way as to carry public opinion with him. At the same time public appreciation of success achieved has the natural effect of stimulating the staff to effect further improvement.

It is curious how old traditions tend to persist—sometimes in the most unexpected quarters. For example, at a recent publicity luncheon under the auspices of the Telephone Development Association, the Chairman, while admitting that the telephone service was making good progress, expressed the view that still better progress might be obtained by private enterprise, and he put forward the suggestion that it would be a good thing if the Postmaster-General could have the assistance of a committee of able business men. On the first point, we are, of course, not unaware of the troubles which beset some of the large private enterprises, such as the railways and the coal mines, or the textile trades, which are of such a character as to intimately affect the life of the community; although, with the close knowledge of our own organisation, we are able, sympathetically, to appreciate the difficulties of their boards of management. On the second point, one would naturally expect the Telephone Development Association to have knowledge of the fact that the Postmaster-General *is* assisted by a committee of business men who are able to render effective help by constructive criticism and to secure the best interests of the public service. Moreover, in all the more important centres throughout the country, Advisory Committees connected with the local Chambers of Commerce have been established, and there is close contact between those committees and the local Post Office officials with a view to the maintenance of a high standard of efficiency. The management of the Post Office is in fact, in some respects, similar to that of the many highly successful municipal trading departments which are run by a trained business staff subject to the over-all control of experienced business men, who are elected to represent and to serve the local communities. The work of the Post Office is gradually becoming better known and better appreciated as a result of publicity methods, and it should be added that much useful work in this respect is being done by the Telephone Development Association.

SUMMARY OF POST OFFICE TELEPHONE ACCOUNTS.

In the "P.O.E.E. Journal," volume 13, part 2, published in July, 1920, an analysis was given of the financial working of the telephone system from the time of purchase of the National Telephone Co.'s undertaking in 1912, up to the financial year ending 31st March, 1919. From the Commercial Accounts for the year ending 31st March, 1924, further interesting information is now available. The following Table shows the balances in the Telephone Net Revenue Accounts for the various years after charging interest on capital, and after allowing for the depreciated value of plant, and all other charges:—

Year.	*Surplus.*	*Deficit.*	*Net Total to Date.*	
			Surplus.	*Deficit.*
	£	£	£	£
1912-13	303,343	—	303,343	—
1913-14	239,111	—	542,454	—
1914 15	—	111,018	431,436	—
1915-16	—	118,177	313,259	—
1916-17	201,729	—	514,988	—
1917-18	355,468	—	870,456	—
1918-19	—	36,261	834,195	—
1919-20	—	1,961,710	—	1,127,515
1920-21	—	4,721,970	—	5,849,485
1921-22	—	559,132	—	6,408,617
1922-23	939,009	—	—	5,496,608
1923-24	1,596,917	—	—	3,872,691
Totals ...	3,635,577	7,508,268	—	3,872,691

The surplus for the year ending 31st March, 1925, amounted to approximately £865,000 : the full accounts for the year have not yet been published. The net deficit to date, which at one time stood at £6,408,617 has thus been reduced to approximately £3,000,000 and the Postmaster-General estimates there will be a further reduction of about £500,000 in the current year's working. The deficit is therefore being gradually worked off; but, even under present conditions, the shortage of £3,000,000, with a capital value of £55,000,000, compares not unfavourably with the depreciated share values of many important industrial undertakings.

The heavy losses in 1919-20 and 1920-21 were due to delay in raising the cost of service to correspond with the increased cost of materials and labour, pending the findings of the Telephone Committee.

Owing to the abnormally high prices prevailing, the revenue was debited with a special depreciation allowance of £200,000 annually from 1920 to 31st March, 1923, making a total of £600,000 for the three years; the " deficit " is increased by this amount in the above figures.

The Revenue Accounts have been debited with a total sum of £1,787,102 in respect of civil pay to telephone staff released for service with the Army and Navy during the War. Further payments in respect of arrears of War Bonus will be chargeable under this head as a result of the Sutton judgment in the House of Lords.

NOTES ON THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH, 1924.

CAPITAL AND INTEREST.

As a general rule, interest is calculated at 3 per cent. on all capital expenditure prior to 1st April, 1912; and, for all subsequent expenditure, at the average Bank rate appropriate to the year in which it was incurred.

The capital of the Telephone Service has been raised mainly by means of Loans under the Telegraph Acts, by Exchequer

Bonds, and by advances provided by the Exchequer out of Voted moneys. On the Loans the interest actually paid is the amount included in the account; on the Bonds the charge is calculated at 3 per cent., the rate at which the Bonds were issued; and on the Exchequer advances the charge is at the average Bank rates for the years in which the advances were respectively made. In financial calculations the present allowance is 4¾ per cent. As compared with this relatively low rate of interest, the Select Committee on the Telephone Service, 1922, found that private companies had to pay dividends at the rate of from 8 to 9 per cent. in order to attract the necessary capital for development purposes. The lower rate of State borrowing is, of course, to the advantage of the telephone users, since the charges on capital have to be met out of the revenue.

In all the accounts, interest on outstanding capital is charged before the balance of profit or loss is determined.

From the 1st April, 1893, to 31st March, 1924, loans amounted to £57,199,482. Of this amount £20,658,607 had been repaid, leaving a balance of £36,540,875 outstanding.

Exchequer Bonds to the value of £7,380,000 had been issued. After allowing for redemption, the balance of the Bonds outstanding amounted to £2,577,400.

The principal items in the Capital Account are shown in the following statement:—

	£
Liabilities.	
Balance of outstanding Loans	36,540,875
Exchequer (Telephone) Bonds	2,577,400
Exchequer advances, &c.	19,359,560
Total	£58,477,835
Less, Expended on Land and Buildings as per separate account	3,562,030
	£54,915,805
Assets.	
Total prime cost value of plant as at 31-3-24	65,367,125
Less, Balance at credit of Depreciation Account	12,725,776
	52,641,349
Value of Stores in stock	2,441,403
	£55,082,752

The cost of Renewals and Displaced Plant is charged to the Depreciation Fund. It is interesting to note that the balance of this fund (shown above) is practically the same as at 31st March, 1919, and approximately twice the amount shown in the accounts for 31st March, 1913. During the year the sum of £2,881,760 was charged to Renewals, and £3,032 to the value of plant permanently displaced. The amount transferred from Net Revenue Account to the Depreciation Fund for the year was £2,843,167. Since 1919 the cost of Renewals has kept nearly level with the amounts set aside for the Depreciation Fund.

The gross revenue for the year was £14,470,049 as compared with £13,918,594 for the previous year. These figures include rentals, fees, trunk calls and value of services to other Departments.

The average number of telephone stations in service during the year 1923-24 was 1,104,582, and the average gross revenue per telephone, therefore, amounted to about £13.

Government Telephone Services.—From 1st April, 1923, Government Departments have, with certain minor exceptions, paid in cash at public rates for the telephone services used by them; prior to that date the value of the services was recorded year by year and credited in the Telephone Accounts.

FEDERATED MALAY STATES.

THE Annual Report for the year 1924 of the Acting Director of the Posts and Telegraphs Department—Mr. T. A. Melville—is a very interesting record of progress. (The Report was published as a Supplement to the "F.M.S. Government Gazette" of 26th June, 1925).

Before 1st January, 1905, each of the States comprised in the Federation (Perak, Selangor, Negri Sembilan and Pahang) had its own postal and telegraph organisation, but on that date the State Departments became merged in the Federal Department, the object being to secure uniformity of procedure throughout the country backed by a common purse.

The year 1924 was noteworthy chiefly for the extensive telephone developments, ten new exchanges being opened and a large number of trunk lines being provided to connect them with the main system and to meet the requirements of the rapidly increasing traffic.

The only retrogression of importance in the Department's statistics was in the number of inland telegrams, which is attributed to the readiness of the public to avail themselves of the trunk telephone service, the fees for which, it is stated, are low compared with those in many other countries.

The following paragraphs of the Report will appeal to many of our readers:—

TELEPHONES.

70. The number of subscribers to the telephone exchange system on the 31st December, 1924, was 2,436, an increase of 226 during the year. In addition there were 1,249 extension lines, extension bells and private circuits maintained by the Department, as compared with 1,093 in 1923.

77. Some press criticism appeared during the year regarding the telephone trunk charges in the Federated Malay States and it was pointed out by the Department that the fees were amongst the lowest in the world. The fee for an ordinary day call between Ipoh and Penang for example, a distance of 117 miles, is only 65 cents. For a similar call in Java the fee would be the equivalent of $1.75, in Denmark 96 cents, in the United States and Canada $1.50, in Australia 80 cents, in New Zealand 93 cents and in Ceylon 76 cents.

ENGINEERING.

84. On the 31st December, there were 2,463 miles of telegraph and telephone lines and 17,373 miles of overhead wire, of which 14,083 miles were telephone wires. In addition there were 55 miles of underground cables containing 5,502 miles of wire, single line. These figures do not include the pole and wires maintained by the Railway Department for their own use. The Posts and Telegraphs Department also owns and maintains 122 miles of line and 367 miles of wire in Johore. It also maintained in addition to its own lines 1½ miles of pole line for Kedah and 211½ miles of wire for Johore.

WORKSHOP.

104. A great variety of work was performed in the workshop, including general repairs and upkeep of all classes of Departmental apparatus and mechanical transport (15 motor vehicles). New classes of work undertaken were cabinet making and joinery, including the construction of wooden arms, office requisites and postal, telegraph and telephone stores and apparatus.

EMPLOYMENT OF MALAYS.

144. In accordance with the policy of the Government, special action was taken during the year to encourage Malays to seek employment in the Department; all branches had instructions to do their utmost in this direction and the co-operation of District

Officers and Inspectors of Schools was invoked. The result was that 76 Malays were appointed during the year as clerks, telephone operators, linesmen, compositors, chauffeurs, postmen, messengers and peons. There is also a long waiting list of applicants, particularly for the post of telephone operator, grade II., all the new exchanges now being opened being operated entirely by Malays.

WIRELESS.

150. The Malayan Wireless Committee met in Singapore on several occasions during the year and submitted reports to Government on the subject of broadcasting, the licensing of wireless receiving stations, of experimental transmitting stations, etc. The reports were forwarded to the Imperial authorities and, after making all necessary adjustments arising out of comments of those authorities, a final report has since been submitted. Arrangements have been made to issue receiving licenses against payment of a small fee. . . . .

NOTES & COMMENTS

NOTES AND COMMENTS.

OWING to the demands upon our space for the elaborate description of the new telephone repeater stations, which will play a very important part in the operation of long distance communications in the immediate future, and a detailed outline of the schemes whereby automatic exchanges can be sandwiched into local telephone networks in non-director areas, we are unable to publish in this issue the promised summary of the Engineer-in-Chief's Institution paper on Automatics. We hope to be able to give this summary, together with the main points of the discussion that followed, in our next issue. Copies of the paper are still available and may be obtained on application to our local agents or from Mr. J. W. Gladwell, Lobby, Engineer-in-Chief's Office.

The Council of the I.P.O.E.E. has decided again to offer five prizes of two guineas each for the five most meritorious essays submitted to it by workmen of the Engineering Department. Particulars of the competition are published at the end of this issue, from which it will be seen a very wide range of subjects is open for essays. The last competition was very successful and a large entry is expected. Papers must be in the hands of the Secretary, I.P.O.E.E., by the 31st December.

The rapid advance in the development of machine switching in telephone exchanges and the consequent impossibility of literature on the subject to keep in phase with the progress being made renders it difficult for telephone engineers and workmen not actually in close touch with those changes to keep abreast of the movement. At most of the polytechnics and technical schools—in London at any rate—classes supported by the Department have been opened for the purpose of teaching the men the principles of the new art. It is not always possible for all members of the staff to take advantage of those classes, but yet every one who has his business at heart must feel the necessity for acquiring a knowledge of the direction in which all telephone switching is moving. We have been asked to announce the formation of a correspondence course on the subject, which has been started by members of the headquarters staff who are actively engaged in the work of changing-over. We can recommend the officers of the "Telephone Tutorial" Staff to our readers as men well-equipped for their undertaking, and trust their labours will be followed by advantage to themselves as we are sure the Department will benefit considerably thereby.

Unit of Transmission.—The discussion of the unit of telephonic transmission to be adopted in Europe was continued at the meeting of the International Consulting Committee in Paris in June, 1925. The choice lay between the use of the attenuation length βl, the "Décie" and the "Transmission Unit" (TU) adopted in 1924 by the Bell Companies of America. The relative characteristics of these units were explained in the Journal for July. The majority of European Administrations expressed themselves in favour of the adoption of "βl." In view, however, of the importance of obtaining uniformity of practice throughout the telephone world the final decision was postponed until arrangements could be made for American representatives to be present to discuss the matter. Pending this discussion it was decided to use "βl" when dealing with international European telephone questions.

Mr. Guy Burney, founder and managing director of the Sterling Company, who retired the other day, is better known perhaps to members of the old N.T. Company's staff than to P.O. men, although his alert upright figure was sometimes seen in the precincts of the G.P.O. He built up a large and successful business and the Company's works at Dagenham cover an area of twelve acres and are laid-out on modern lines with shops equipped with the latest machine tools for mass production. Mr. Burney realised quickly the immense future for radio work and took full advantage of the broad-casting boom. He was a believer in early retirement and has acted up to his belief. In an interview he said "It is better to enjoy the fruit of happiness while there is still some life left in the old dog; besides it leaves the door open to the younger men."

We note with interest the fact that an experimental rural automatic exchange on the Relay system was installed some time ago in Switzerland. As a result of the experience gained on this type of equipment we understand that a further 20 rural exchanges are being similarly equipped. The problem of giving service to rural communities is an interesting and important one and all Administrations feel the desirability of giving that service automatically on a 24-hour basis. As to whether automatic equipment designed on a *ratchet and pawl* or *relay* basis is the correct development, various authorities hold different opinions and it will be interesting to see the results of this somewhat extensive trial in Switzerland. It is satisfactory to note that English produced telephone plant is securing a footing on the Continent.

The Relay Automatic Telephone Co. has just cut-over a large P.A.B.X. of 550 lines for the Admiralty at one of H.M. Naval Establishments. Standard dialling, ringing and B.B. tones are provided and arrangements are made for holding conferences of officials through the medium of the exchange. Two sets of 32 v. 340 A*h* chloride cells and duplicate ringing machines have been installed.

The L.M.S. Railway has been provided with an automatic telephone equipment at Victoria Station, Manchester, with an ultimate capacity of 800 lines by the A.T.M. Co., Liverpool. Inter-communication with the public service will be afforded by an associated manual switchboard. The manufacturing company has sent us a beautiful print of a photo taken from the air of their extensive works at Milton Road, Edge Lane, Liverpool. The ground area occupied by the works is 9½ acres, while extensions are still in progress.

Messrs. Creed and Co., the well-known manufacturers of telegraph apparatus, have intimated that "they have purchased Mr. Donald Murray's Telegraph business, including the Murray Telegraph Patents, and shall in future manufacture and supply the Murray Multiplex and other Murray apparatus. Mr. Murray will for a time give the Company the benefit of his valuable experience." Old telegraph men will remember that Messrs. Creed and Murray were in partnership before and we trust their re-union or absorption, whichever it may be, will be free from estrangements which divorced those able pioneers of printing telegraphs so long. We can scarcely conceive Mr. Donald Murray being content with merely contributing valuable advice; nor can we accept his paper on "Speeding up the Telegraphs" as his Swan-song.

The Managing Editor, I.P.O.E.E. Journal.

Dear Sir,—I was much interested in Mr. Hill's letter, published in the July issue of the Journal, in which he has very kindly added useful supplementary information to my article on the theory of the shunted condenser.

The question raised by Mr. Hill as to what precisely happens in the circuit under discussion when the mathematical equation $L = CR^2$ holds good is important and I should like to add some further notes on this point.

Before doing so, it may be interesting to point out that the equation (2) given in my article is not necessarily of an oscillatory form when the condition $L = CR^2$ is true. In order to prove this, let us examine the equation referred to. If it is oscillatory in form then β must be an imaginary quantity,

i.e., $\left(\frac{R_1}{2L} - \frac{G}{2C}\right)^2 - \frac{1}{LC}$ must be negative.

If $L = CR^2$ this condition becomes—

$(R_1 - 3R)(R_1 + R)$ must be negative,

i.e., R must be greater than $\frac{1}{3}R_1$.

So that it follows that the resistance used to shunt the condenser must be greater than one-third of the relay resistance if, when $L = CR^2$, my equation (2) is to be of the same form as equation (2) given in Mr. Hill's letter. In practice this condition is generally fulfilled.

But what does precisely happen in this circuit with the usual values of R if CR^2 is made equal to L? To answer this question let us consider the circuit shown in Fig. 1.

On depressing the key a voltage V is suddenly applied to the shunted condenser arrangement and on releasing the key the circuit is suddenly discharged. The current i_C passing through the relay on depressing the key is given by equation (2) in my article; the current i_D in the relay on releasing the key is given by:—

$$i_D = -\frac{V}{R+R_1}e^{-at}\left[\frac{(R+R_1)-L(\alpha+\beta)}{2L\beta}e^{+\beta t} - \frac{(R+R_1)-L(\alpha-\beta)}{2L\beta}e^{-\beta t}\right] \quad \ldots\ldots\ldots\ldots (a)$$

Equation (a) assumes that the condenser is fully charged up to the voltage $V \times \dfrac{R}{R+R_1}$ before the key is released.

Now, if $L = CR^2$, and also equation (a) is of the oscillatory form then it follows that the *quantity* of electricity passing through the relay on suddenly discharging the circuit is zero. If a truly ballistic galvanometer were placed in the circuit in the position shown dotted in Fig. 1, it would not be affected. This then is the significance of the relation $L = CR^2$, and the truth of this statement will now be proved.

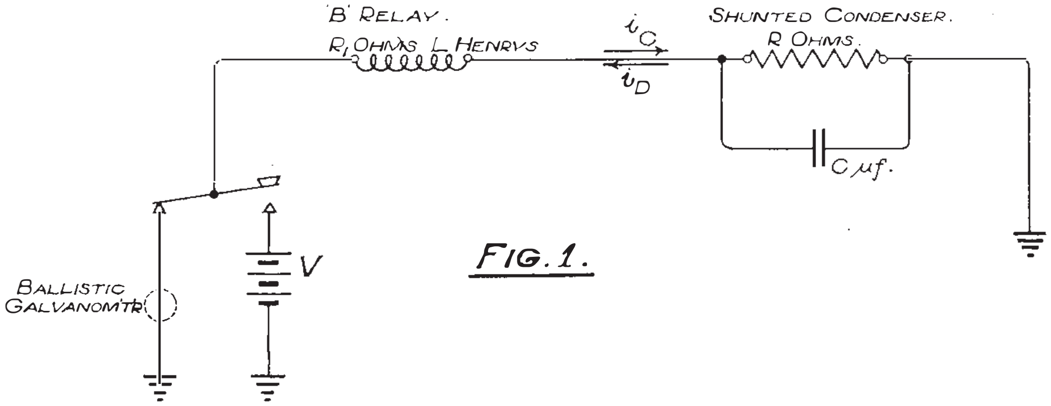


FIG. 1.

The quantity of electricity passing through the relay on releasing the key is given by—

$$q_D = \int_{t=0}^{t=\infty} i_D \, dt \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (b)$$

When the discharge is oscillatory the value of i_D in equation (a) may be written—

$$i_D = \frac{V}{R+R_1} e^{-at} \left[\cos \beta_1 t - \frac{R+R_1-La}{L\beta_1} \sin \beta_1 t \right] \qquad \ldots\ldots\ldots (c)$$

where $\beta = j\beta_1 = \sqrt{-1}\,\beta_1$

$$\therefore \; q_D = \frac{V}{R+R_1} \int_{t=0}^{t=\infty} e^{-at} \left[\cos \beta_1 t - \frac{R+R_1-La}{L\beta_1} \sin \beta_1 t \right] dt$$

If $L = CR^2$ this reduces to

$$q_D = \frac{V}{R+R_1} \left[\frac{e^{-at} \sin \beta_1 t}{\beta_1} \right]_{t=0}^{t=\infty}$$

$$= 0$$

Therefore, q_D is zero when $L = CR^2$ *and* the discharge current is oscillatory.

This point will perhaps be made quite clear by means of an illustrative numerical example.

Suppose $L = 3.5$ henrys
,, $R_1 = 300$ ohms
,, $R = 700$ ohms
,, $C = \dfrac{L}{R^2} = 7.14\ \mu.f.$
and $V = 1$ volt

Then using these figures, the charge current i_C has been calculated by means of equation (2) of my article and the discharge current i_D has been calculated by using equation (a) given in this letter. The results are given in the table which follows:—

t secs.	i_C m.a.	i_D m.a.
0.000	0.000	1.000
0.001	0.272	0.728
0.002	0.513	0.487
0.003	0.717	0.283
0.004	0.885	0.115
0.005	1.017	−0.017
0.008	1.226	−0.226
0.010	1.249	−0.249
0.015	1.136	−0.136
0.020	1.017	−0.017
0.025	0.977	0.023
0.030	0.984	0.016
0.040	1.002	−0.002
0.050	1.0007	−0.0007

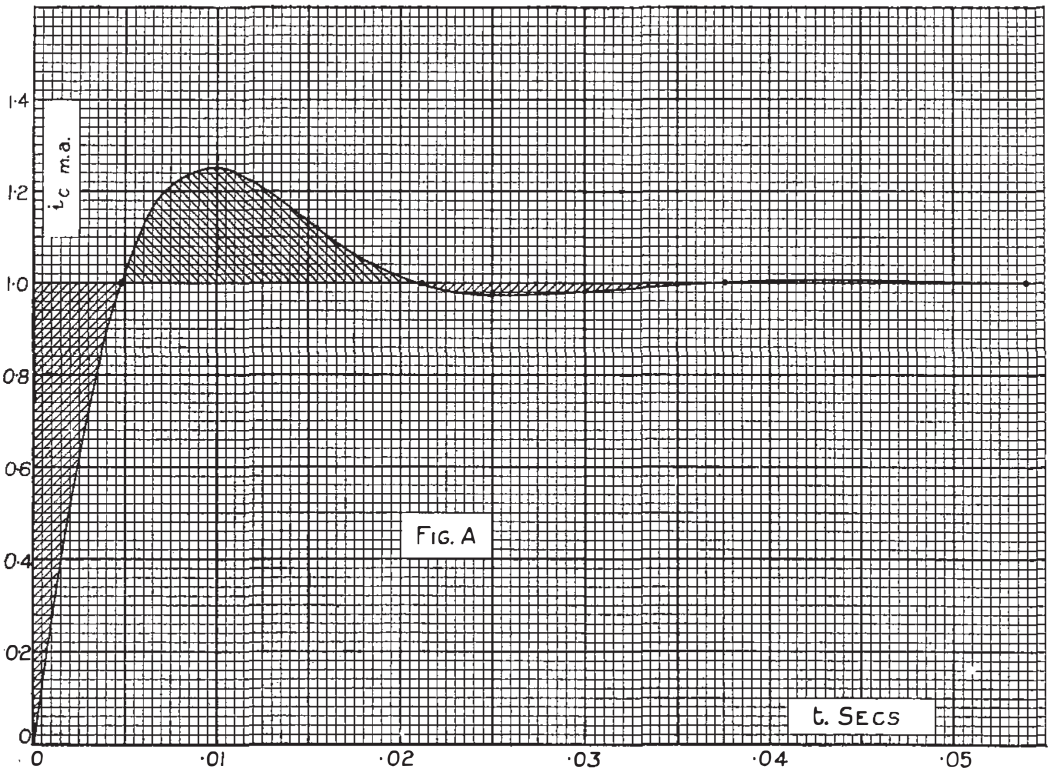


Fig. A

These tabulated values of i_C and i_D are plotted on Figs. A and B respectively. In Fig. B, if the curve were continued to $t=\infty$, the sum of the areas shaded from right to left would be equal to the sum of the areas shaded from left to right. The former areas are above the zero line and the latter are below the zero line. Hence the net quantity of electricity flowing through the relay coils on releasing the key is zero, when $L=CR^2$. Considering Fig. A the sum of the shaded areas above the horizontal line drawn at a current of 1 m.a. is equal to the sum of the shaded areas below this line. I think that this shows the theoretical condition of affairs when $L=CR^2$ and the charge and discharge curves are oscillatory. Other conditions being the same, the greater the value of CR^2 the more rapidly does the current rise and fall in the relay coils on depressing and releasing the key respectively.

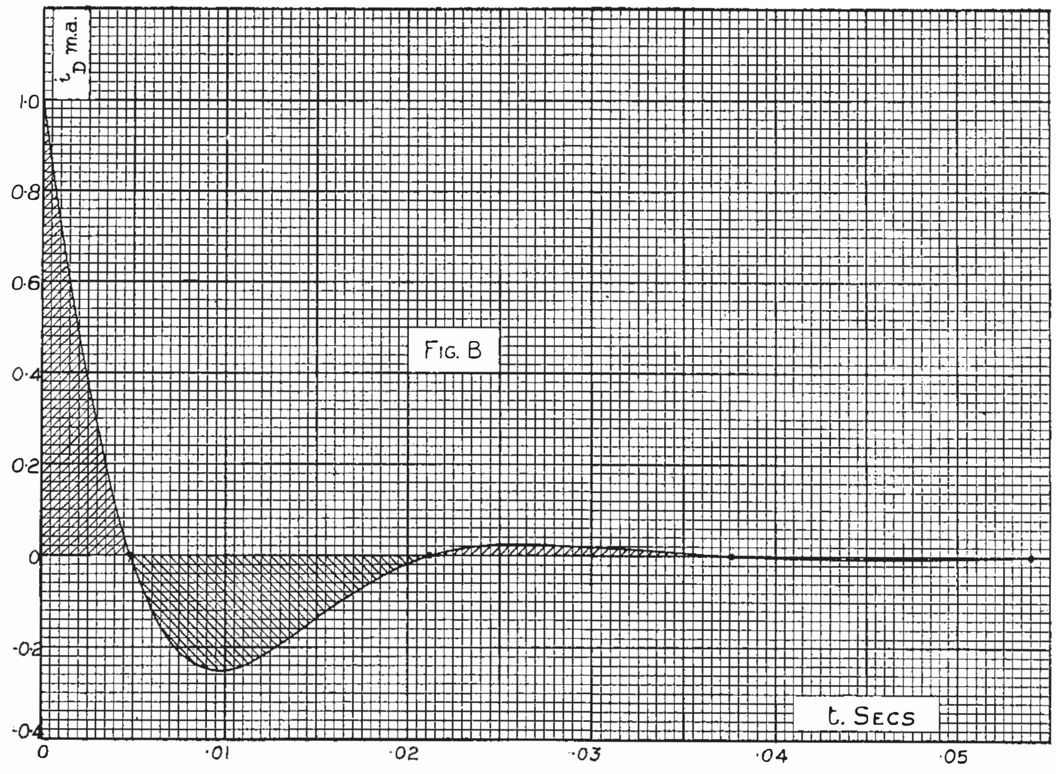


Fig. B

In using the rule $L=CR^2$ in practice it seems to me that the main difficulty is to decide what is the value of L; in the case of a " B " relay or Wheatstone receiver L is by no means a constant as was shown by the experimental results given in my article.

I am, dear Sir,
Yours faithfully,
A. B. Morice.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Dudley Extension ...	Auto	300
Portsmouth Extension ...	,,	—
Albert Docks New ...	Manual	1600
Enfield Extension ...	,,	450
Buxton New	,,	300
Canterbury Extension ...	,,	340
Ealing ,, ...	,,	1680
Leeds Trunk ,, ...	,,	—
Palmers Green New ...	,,	2200
Cloans M.F.	,,	—
Whitley Bay New ...	,,	800
Benton & Stone	P.A.B.X.	40
Bury Co-op. Society ...	,,	50
W. & G. Du Cros ...	,,	50
Dunlop Rubber Co. ...	,,	80
Gardner & Co.	,,	60
J. & J. Hayes	,,	40
Langs Bread	,,	25
Nairn & Co.	,,	80
P.L.A. Head Office ...	,,	200
P.L.A. St. Katherine's Dock	,,	70
Prudential Assurance Co...	,,	400
Shell-Mex, Glasgow ...	,,	30
Shell-Mex, Manchester ...	,,	30
Shell-Mex, Tunbridge Wells	,,	25
Wallpaper Manufacturers, Ltd.	,,	25
Wilderness Country Club	,,	40

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Ainsdale	Auto	618
Birkdale	,,	1100
Chesterfield	,,	925
Churchtown	,,	921
Cosham	,,	160
Exeter	,,	1990
Hayling Island	,,	107
Sheffield Central	,,	6300
Southport	,,	3000
Staveley	,,	50
Topsham	,,	90
Beaconsfield	Manual	660
Bexley Heath	,,	780
Burgh Heath	,,	1650
Coatbridge	,,	600
Huddersfield Desk ...	,,	—
Leigh (Lancs.)	,,	680
London Toll (New) ...	,,	2350
Walton-on-Thames ...	,,	1040

Exchange.	Type.	No. of Lines.
Amalgamated Dental ...	P.A.B.X.	50
Appleyard Ltd.	,,	30
Barrow Hepburn & Gale	,,	70
Battersea Council ...	,,	70
Benson Ltd.	,,	70
Chad Valley Co.	,,	30
Clark Hunt & Co. ...	,,	40
Coults & Co.	,,	50
Delaney & Co.	,,	30
Featherstones Ltd. ...	,,	30
Johnson	,,	30
Kenrick & Jefferson ...	,,	40
Ledingham & Sons ...	,,	30
Lines Bros.	,,	50
McNamara & Co.	,,	80
Navy, Army & Air Force Institute	,,	190
Prices Candle Co. ...	,,	70
Robinson, E. S. & A. ...	,,	80
Robinson, J. & H. ...	,,	40
Scottish Oils	,,	63
Shanks & Co.	,,	40
Shell-Mex, Tunbridge Wells	,,	30
Union Cold Storage ...	,,	230
Waddington Ltd.	,,	30
Wagon Repairs	,,	40

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
Aberdeen	Manual	1520
Birmingham Central ...	,,	1250
Chiswick	,,	1500
Guildford	,,	540
Huddersfield	,,	720
Hull Toll	,,	—
Leeds Trunk	,,	—
Ramsgate	,,	380
St. Annes-on-Sea	,,	540
Trafford Park	,,	520
Truro	,,	100
Woking	,,	300

LONDON ENGINEERING DISTRICT.

Mileage Statistics.

During the three months ended 30th June, 1925, the following changes have occurred:—

Telegraphs.—Nett decrease in open wire of 154 miles and a nett increase in underground of 318 miles.

Telephones (Exchange).—Nett decrease in open wire (including aerial cable) of 1,196 miles and a nett increase in underground of 38,584 miles.

Telephones (Trunks).—Nett increases in open wire and underground of 1 mile and 2,227 miles respectively.

Pole Line.—Nett increase of 60 miles, bringing the total to date to 5,138 miles.

Pipe Line.—Nett increase of 187 miles, the total to date being 6,091 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	24,031
Telephones (Exchange)	1,610,388
Telephones (Trunks)	55,553
Spares	47,343

EXTERNAL CONSTRUCTION.

During the quarter ended 26th June, 1925, 9,968 exchange lines, 6,364 internal extensions and 1,302 external extensions were provided. In the same period 2,974 exchange lines, 2,851 internal extensions and 610 external extensions were recovered, making nett increases of 6,994 exchange lines, 3,513 internal extensions and 692 external extensions.

INTERNAL CONSTRUCTION.

New Exchanges.—During the past quarter new Manual Exchanges have been opened at Enfield (C.B.1, 1,840 lines), Albert Docks (C.B.1, 1,500 lines) and Sloane temporary—(C.B.10, 2,760 lines). A new Manual Exchange at East Ham (C.B.1, 1,700 lines) is in course of construction.

The construction of the Automatic Exchanges at Holborn and Bishopsgate, and of the Tandem Exchange is proceeding. The provision of the Coder Call Indicator equipment, which is to be provided at all Manual Exchanges affected by the introduction of automatic working, has commenced.

Exchange Extensions.—Extensions and modifications of the exchange equipment at seventy of the Exchanges in the London District are in hand.

P.A.B.X.'s.—The Private Automatic Branch Exchange installation supplied under contract by Messrs. Siemens Brothers for the Port of London Authority was formally opened by Lord Ritchie, the Chairman of the Authority, on July 27th, in the presence of representatives of the Authority, the Department, the Contractors and public bodies. The installation consists of Automatic Exchanges at the Head Office in Trinity Square, London, and St. Katherine's Dock, East & West India and Millwall Docks, Victoria & Albert Docks and Tilbury. Manual Boards are located at the Head Office and at Tilbury only. Incoming calls for all the Docks, with the exception of Tilbury, pass through the manual board at the Head Office. The extensions on the Docks Installations dial the nearest public Exchange direct for outgoing service, and intercommunication between extensions on the installations of the various Docks is effected automatically over tie lines concentrated on the Head Office. A fuller description appears elsewhere in this issue.

TELEGRAPHS.

FIGURE No 1.

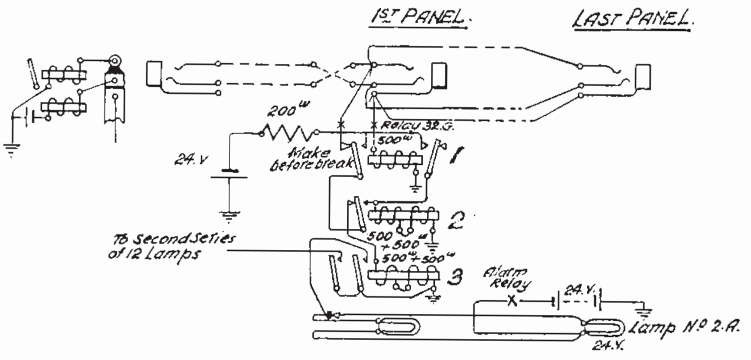


FIGURE No 2.

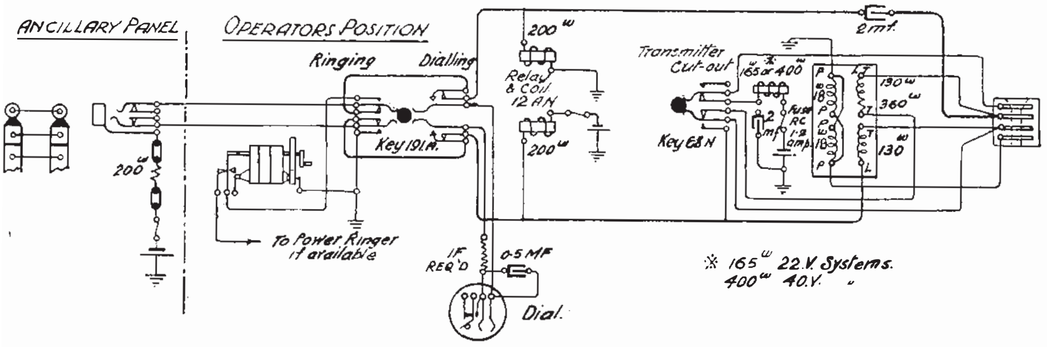
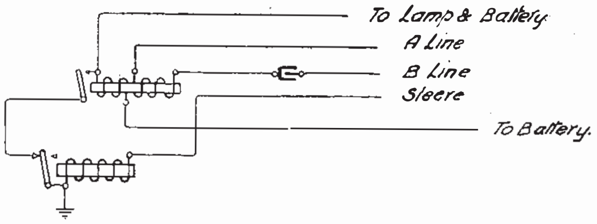


FIGURE No 3. BOTHWAY CIRCUIT.



Concentration of Phonograms at Central Telegraph Office.

Between the hours of 10 p.m. and 7 a.m., a percentage of Phonogram junctions, consisting of outgoing junctions to Central and Trunk Exchanges, and incoming from Central, and one Bothway Junction from Waterloo Railway Station, are switched by means of break-jacks from the Main Phonogram Switchboard on the first floor of the C.T.O. to a concentrator which has been fitted in the Central Hall on the ground floor. The stalls occupy two tables on the east side of the room. The circuits are multipled to five small switchboards, and provision has been made for 15 operators. The whole installation is self-contained, the fuse-board, relays, etc., being enclosed in a cabinet on the north side of the room.

The line circuit is shown in Fig. No. **1**. A current from the distant Exchange on the " B " line operates No. 3 relay, lighting the calling lamp.

When the operator plugs into the jack the battery on the sleeve operates No. 1 relay and this in turn operates No. 2 which, being slow-acting, will retain if the distant Exchange has not cleared when the Phonogram operator withdraws his plug on the completion of conversation. The operator's jack and speaking circuit is shown in Fig. No. **2**, the Keys being for the purpose of cutting out the operator's transmitter and for ringing on the both-way circuits. A diagram of the latter is shown in Fig. No. **3**, connection from the operator's jack to the multiple being made by a looping cord.

The room in which the concentrator is installed is particularly suitable for this purpose, as on the west side are situated the Pneumatic Tube services which convey telegrams to and from all the principal Post Offices and Cable Companies in London. The room, being decidedly smaller than the main Phonogram room, results in economy in lighting, heating and staffing, and is generally more convenient for all concerned during the slack hours.

THE POST OFFICE TELEPHONE AND TELEGRAPH SOCIETY OF LONDON.

Session 1925-26.

Meetings will be held at the Institution of Electrical Engineers, Victoria Embankment, W.C.2, at 5.30 p.m.

1925. *Programme.*

October 19th. " London Telephone Service." M. C. Pink, Esq. (Assistant Controller London Telephone Service).

November 16th. " Wireless Telegraphy and its Application to Ship and Shore Work." Comdr. F. G. Loring, R.N. (Inspector of Wireless Telegraph G.P.O.).

December 21st. " Fifty Years of Telephone Progress." W. Day, Esq., M.I.E.E. (Engineer-in-Chief's Office, G.P.O.).

1926.

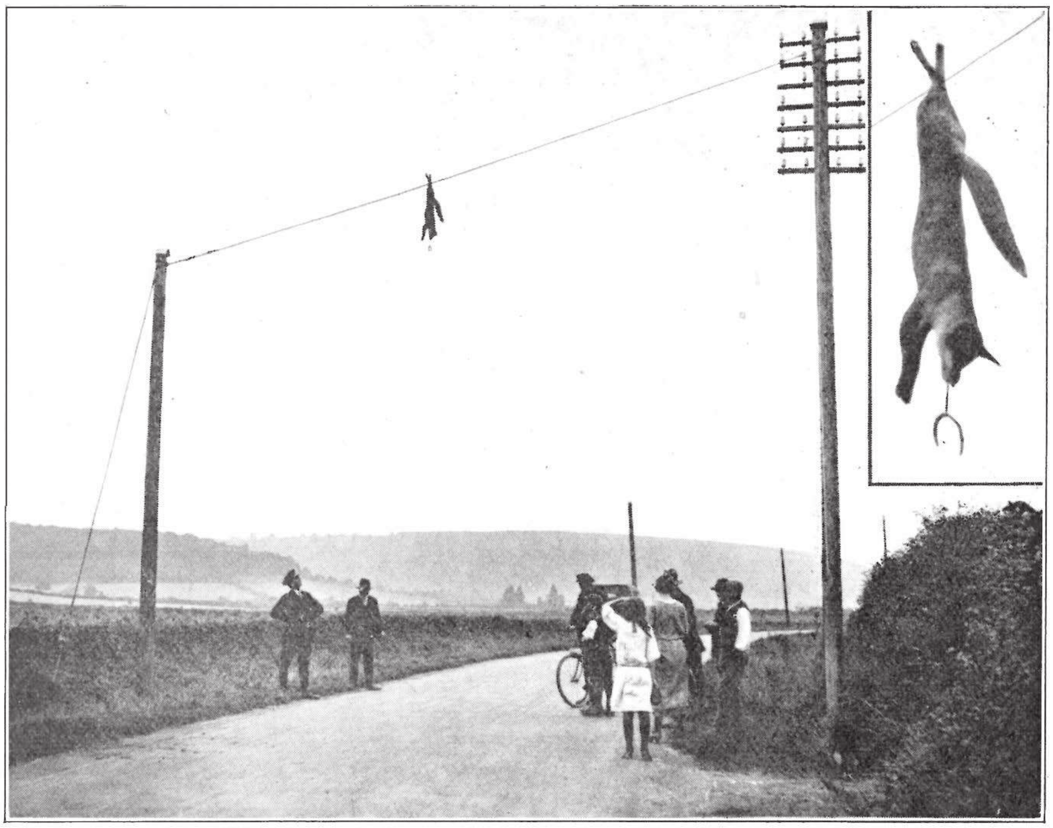
January 18th. " Recent Developments in the Inland Telegraph Service." L. Simon, Esq. (Assistant Secretary G.P.O.).

February 15th. " Some Sidelights on the International Telegraph Conference." J. Lee, Esq., C.B.E. (Controller, Central Telegraph Office).

March 15th. (*a*) "Internal Circulation in the Central Telegraph Office." (*b*) "Phonograms." Miss M. Tynan (Assistant Supervisor Central Telegraph Office).

April 19th. "Wireless." E. H. Shaughnessy, Esq., O.B.E., M.I.E.E., M.I.R.E. (Assistant Engineer-in-Chief G.P.O.).

A NEW USE FOR AERIAL STAY WIRES.



A dead fox was found hanging, as shown, above the Hereford-Leominster Road the other week. The photo appeared in the *Hereford Times*, from whom we are indebted for the loan. On the right is a close-up snap of the fox.

BOOK REVIEWS.

"An Outline of Automatic Telephony." By William Aitken. E. Benn, London.

This little volume is an attempt—and a very praiseworthy attempt—to cover, within the limits of a hand-book, descriptions of the automatic telephone systems in use in the world to-day. It thus really takes the form of an abridged edition of the author's well-known treatise, to which it may serve as an introduction.

On the whole the attempt is very successful, though the inclusion of so many systems restricts the amount of space that can be given to each.

But it is not surprising that, in a book dealing with a subject so rapidly changing as automatic telephony, a few errors are apparent.

Thus, the lettering on the dial shown in Fig. 5 is not that which has been adopted for London. Again, on page 85 it is stated that slip wiring has been generally used and will continue to be used to a considerable extent on selector banks. Though this may be true by itself, it follows immediately after a description of grading, and the advantages obtained by means of grading are almost entirely lost if slip wiring is employed. Slip wiring has been practically abandoned by the Post Office.

As is usual in Mr. Aitken's books, the diagrams are clear, and the reproduction, too, is excellent. In tracing circuits the author's bus-routing scheme, familiar from its employment in the larger work, is extensively used.

G. F. O'DELL.

BOOKS RECEIVED.

"Dictionary of Technological Terms used in Electrical Communication. Part I, English—German." By O. Sattelberg, Telegraphentechnische Reichsamt, Berlin. Julius Springer, Berlin. 9 gebunden goldmark.

"Electricity and the Structure of Matter." L. Southerns, M.A., B.Sc. Oxford University Press, London. 2*s*. 6*d*. net.

PAPERS RECEIVED.

The Selected Papers from the Journal of the Institute of Electrical Engineers of Japan.

No. 1. The Electromagnetic Induction and the Effective Self-Inductance of a Rectilinear Transmission Line with Earth Return, and the Potential Difference on the Earth Surface. Hidetaro Ho. Member.

No. 2. On the Continuity of Vector Power in an Alternating Electric and Magnetic Current Field. Heiichi Nukigama, Member.

No. 3. On the Induction Synchronous Motor characterised by Automatic Transmission. Tadaoki Yamamoto, Member.

No. 4. Transient Phenomena in a Short-Circuited Alternator. Taro Otake, Member.

No. 5. Jump in the Self-Excitation of D.C. Generators. Masataro Kawarada, Member.

No. 6. New Method for Electrical Machine Design. Jutaro Takenchi, Member.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Blick, F.	Assistant Engineer, London District.	Executive Engineer, E.-in-C. Office.	30-6-25
Stone, H. C.	Assistant Engineer, London District.	Executive Engineer, London District.	28-7-25
Prescott, J.	Chief Inspector, London District.	Assistant Engineer, London District.	16-8-25
Martin, P. C.	Chief Inspector, N. Wales District.	Assistant Engineer, N. Wales District.	8-9-25
Gresswell, F. P.	Chief Inspector, N. Wales District.	Assistant Engineer, S. West District.	20-8-25
White, H.	Chief Inspector, London District.	Assistant Engineer, London District.	To be fixed later.
Roberts, F. H.	Inspector, N. Mid. District.	Chief Inspector, N. Mid. District.	7-4-25
Croughton, G. F.	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	12-4-25
Kennard, E. G.	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	19-4-25
Bagley, T.	Inspector, N. Mid. District.	Chief Inspector, N. Mid. District.	7-5-25
Beighton, T. A.	Inspector, N. Mid. District.	Chief Inspector, S. Mid. Ditrict.	17-5-25
Cornish, G.	Inspector, S. East District.	Chief Inspector, S. East District.	24-5-25
Whenmouth, H.	Inspector, London District.	Chief Inspector, London District.	16-8-25
Clifford, F.	Inspector, London District.	Chief Inspector, London District.	22-7-25
Cuthbert, C. T.	Inspector, London District.	Chief Inspector, London District.	26-7-25
Scarborough, H.	Inspector, N. East District.	Chief Inspector, S. Wales District.	13-7-25
Hargreaves, T.	Inspector, N. West District.	Chief Inspector, E.-in-C. Office.	4-8-25
Meek, L.	Inspector, N. Mid. District.	Chief Inspector, E.-in-C. Office.	14-8-25
Rafferty, A.	Inspector, Scot. W. District.	Chief Inspector, Met. Power District.	To be fixed later.
Christie, G. C.	Inspector, N. Mid. District.	Chief Inspector, N. Wales District.	To be fixed later.
Hodge, H. R.	Inspector, N. Mid. District.	Chief Inspector, N. Wales District.	To be fixed later.
Martin, J. A. S.	Repeater Officer, Cl. II., Lowestoft.	Chief Inspector, E.-in-C. Office.	To be fixed later.
Towle, E. H. N.	Inspector, London District.	Chief Inspector, London District.	To be fixed later.
Buckley, T.	Skilled Workman, Class I., London District.	Inspector, London District.	11-1-25
Faulkner, W.	,,	,,	1-4-24
Wenman, G. A.	,,	,,	29-6-24
Bull, C.	,,	,,	5-4-25
Pearson, M.	,,	,,	1-7-24
Deboise, A. S.	,,	,,	25-8-24
Ives, G. T.	,,	,,	5-1-25
Nye, C. P.	,,	,,	25-8-24
Allen, A. G. R.	,,	,,	8-4-25
Rhodes, E. R.	,,	,,	25-8-24
House, R.	,,	,,	8-4-25
Endacott, J.	,,	,,	25-8-24

PROMOTIONS.—continued.

Name.	Grade.	Promoted to.	Date.
Greenwood, G. F.	Skilled Workman, Class I., London District.	Inspector, London District.	1-9-24
Goater, H. W.	,,	,,	25-8-24
Searle, C. T.	,,	,,	25-8-24
Streatfield, F. G.	,,	,,	5-1-25
Simpson, W. F.	,,	,,	5-4-25
Stace, C. F.	,,	,,	5-10-24
Chapman, E. J.	,,	,,	7-10-24
Lee, J. A.	,,	,,	1-12-24
Elsey, W.	,,	,,	1-12-24
Young, H. T.	,,	,,	5-1-25
Evans, J. W.	,,	,,	14-12-24
Brient, A.	,,	,,	8-4-25
Maltby, W. A.	,,	,,	7-4-25
Hatfield, W.	,,	,,	8-4-25
Lumber, A. J.	,,	,,	14-12-24
Lovell, R. W. R.	,,	,,	14-12-24
Matthews, B. T.	,,	,,	5-4-25
Heath, C. A. F.	,,	,,	14-12-24
Flack, W. E.	,,	,,	17-12-24
Boughey, S. H.	,,	,,	7-4-25
Connor, C. H.	,,	,,	7-4-25
Norman, A. E.	,,	,,	1-1-25
Sperrey, H.	,,	,,	14-4-25
Rivers, H. G.	,,	,,	1-1-25
Bydawell, L. S.	,,	,,	8-4-25
Roberts, G. E.	,,	,,	3-1-25
Scott, E. H. G.	,,	,,	11-1-25
Tyler, H. G.	,,	,,	8-4-25
Foxcroft, J. R. M.	,,	,,	8-4-25
Chambers, A. W.	,,	,,	5-1-25
Thraves, J. J.	,,	,,	5-1-25
Doughty, E. M.	,,	,,	14-2-25
Pratt, A. W.	,,	,,	7-4-25
Pollard, W. T.	,,	,,	5-4-25
Mabbutt, E.	,,	,,	11-2-25
Foster, A. T.	,,	,,	5-1-25
Capon, S.	,,	,,	5-1-25
Rogers, H.	,,	,,	5-1-25
Twaites, C. H.	,,	,,	9-4-25
Hodgson, F. M.	,,	,,	6-4-25
Diplock, H.	Skilled Workman, Class I., S. East District.	Inspector, S. East District.	8-10-24
Farrow, A. A.	,,	,,	5-1-25
Little, E. A.	,,	,,	5-1-25
Trist, W. E.	,,	,,	5-1-25
Sell, A. S.	,,	,,	5-1-25
Roebuck, J. J. R.	,,	,,	5-1-25
Maltby, D. H.	,,	,,	5-1-25
Viersen, F.	,,	,,	5-1-25
Eager, A.	,,	,,	5-1-25
Parsons, E.	,,	,,	4-5-25
Thomson, A.	,,	,,	25-8-24
Denton, W. T.	,,	,,	5-1-25
Powell, S. J.	,,	,,	5-1-25
Richardson, R. B. H.	,,	,,	25-8-24
Creed, H.	,,	,,	25-8-24
Walton, W. R.	,,	,,	1-5-25
Cooper, L. E.	,,	,,	2-5-25
Smith, F. C.	,,	,,	5-1-25
Smith, H. A.	,,	,,	5-1-25
Bridger, A. S.	,,	,,	5-1-25
Stainer, W. H.	,,	,,	5-1-25

STAFF CHANGES.

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Janks, F. A. E. ...	Skilled Workman, Class I., S. East District.	Inspector, S. East District.	5-1-25
Grainger, C. H. ...	,,	,,	5-1-25
Johnson, E. W. ...	,,	,,	1-5-25
Twort, H. S.	,,	,,	25-6-25
Boyce, C. T.	Skilled Workman, Class I., N. Ireland District.	Inspector, N Ireland District.	1-4-25
Cattle, F.	Skilled Workman, Class I., Testing Branch.	Inspector, Testing Branch.	19-4-25
Rowe, A. W.	,,	,,	12-4-25
Nicoll, D. A. D. ...	,,	,,	24-6-25
Smith, J. R.	Shift Officer, Wireless Station, Oxford.	Inspector, Rugby.	1-4-25
Sheppard, A. C. ...	,,	Inspector, Oxford.	18-7-25
Wain, S. W.	,,	Inspector, Northolt.	2-7-25
Stroulger, A. J. ...	Skilled Workman, Class I., E. District.	Inspector, East District.	1-4-25
Darkin, J.	,,	Inspector, East District.	1-7-25
Grieve, P. R.	Skilled Workman, Class I., S. Lancs. District.	Inspector, S. Lancs. District.	15-3-25
Scott, J.	Skilled Workman, Class I., Scot. W. District.	Inspector, Scot. West District.	26-7-25
Thompson, W. ...	,,	Inspector, Scot. West District.	9-3-25
Measey, W. F. ...	,,	Inspector, Scot. West District.	9-3-25
Hulton, H. H. ...	Skilled Workman, Class I., S. West District.	Inspector, S. West District.	10-3-25
Fegan, G. R. F. ...	,,	Inspector, S. West District.	31-3-25
Simpson, D. A. ...	Skilled Workman, Class I., Scot. East. District.	Inspector, Scot. East District.	30-7-25
Butterworth, H. ...	Wayleave Officer, N.W. District.	Inspector, N. West District.	27-8-25
Wilton, D. V. ...	Wayleave Officer, London District.	Inspector, London District.	28-5-25
Seller, W. G.	Wayleave Officer, London District.	Inspector, London District.	28-5-25
Shields, A. V.	Telegraphist, C.T.O.	Repeater Officer, Class II.	29-4-25

REVERSION.

Name.	Grade.	Reverted to.	Date.
Bull, C. E.	Chief Inspector, London District.	Inspector, London District. (At own request.)	18-8-25

STAFF CHANGES.

APPOINTMENT.

Name.	Grade.	Appointed.	Date.
McDonald, A. G. ...	Probationary Assistant Engineer. E.-in-C. Office.	Assistant Engineer. E.-in-C. Office.	1-9-25

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From.	To.	
McMurray, C. H...	Asst. Engineer.	S. West Dist.	S. Wales Dist.	23-8-25
Horn, T. ...	Chief Inspector.	S. Wales Dist.	E.-in-C. Office.	18-6-25

DEATHS.

Name.	Grade.	District.	Date.
Patterson, T.	Executive Engineer	London	8-6-25
Yule, J.	Assistant Engineer	South West	28-8-25
Sutton, G.	2nd Cl. Engineer	Testing Branch	9-9-25
Watt, J.	Inspector	Scotland East	6-7-25
Humber, J.	,,	East	18-7-25

RETIREMENTS.

Name	Grade.	District.	Date.
Williams, E.	Inspector	S. Wales	28-8-25
Pendreigh, W.	,,	London	9-5-25

CLERICAL ESTABLISHMENT.

PROMOTION.

Name.	Grade.	Promoted to	Date.
Freeman, S. M. ...	Executive Officer, E.-in-C. Office.	Higher Exec. Officer, E.-in-C. Office.	13-7-25
Henderson, G. F. H....	Clerical Officer, E.-in-C. Office.	Executive Officer, E.-in-C. Office.	1-3-25
Scrafton, C. D. ...	Clerical Officer, N. District.	Higher Clerical Officer, N. Mid. District.	1-7-25
Thompson, J. T. ...	Clerical Officer, S. Mid. District.	Higher Clerical Officer, S. East District.	21-6-25
Edwards, A.	Clerical Officer, East District.	Higher Clerical Officer, East District.	14-2-25
Pratt, C. W.	Clerical Officer, N. District.	Higher Clerical Officer, S. Wales District.	21-7-25
Corney, P. A.	Clerical Officer, S. Mid. District.	Higher Clerical Officer, S. West District.	12-8-25
Coleman, A. T. ...	Clerical Officer, S. West District.	Higher Clerical Officer. S. Wales District.	16-8-25

STAFF CHANGES.

APPOINTMENTS AS CLERICAL OFFICER.

Name.	District.	Date.
Leatherbarrow, J.	S. Lancs.	1-5-25
Morrison, C. T.	N. Mid.	17-5-25
Ruddy, T .H.	S. Lancs.	17-5-25
Russell, J. C.	E.-in-C. Office	24-5-25
Saxon, T. H.	S. Lancs.	24-5-25
Earlam, T.	do.	24-5-25
Chambers, J. W.	do.	31-5-25
Kemmery, H. W.	S. West	31-5-25
Randall, P.	Met. Power	21-6-25
Kelly, P.	S. Lancs.	21-6-25
Hanwell, J.	N.	1-7-25
Frew, A.	N. East	2-8-25
Bywater, F. L.	N. Mid.	23-8-25
Thomas, W. E.	S. Mid.	23-8-25
Johns, R. L.	E.-in-C. Office	20-9-25

TRANSFERS.

Name.	Rank.	Transferred.		Date.
		From.	To.	
Brown, C.	Hr. Clerical Officer.	S.E. Dist.	S. West. Dist. ,,	1-7-25
Timms, R. H.	Clerical Officer.	I. of W.T.'s Staff.	Leafield W.T. Station.	1-4-25
Laughton, E.	,,	Savings Bank Dept.	Sc. E. Dist.	14-5-25
Milne, J.T.	,,	Sc. E. Dist.	Savings Bank Dept.	14-5-25
Lyford, G. S.	,,	N. Dist.	S. Mid. Dist.	1-6-25
Neale, H. B.	,,	London.	S. East. Dist.	13-6-25
Betts, G.	,,	N. West. Dist.	S. Mid. Dist.	14-6-25
Booth, H. T.	,,	S. Lancs. Dist.	N. West. Dist.	14-6-25
Farrand, S.	,,	S. Lancs. Dist.	N. West. Dist.	14-6-25
Dawson, A. A.	,,	N. West. Dist.	Sc. E. Dist.	14-6-25
MacKenzie, W. M.	,,	S. East. Dist.	London Postal Service.	14-6-25
Allen, L. R. S.	,,	Met. Power Dist.	Board of Control.	22-6-25
Lightfoot J.	,,	Ministry of Pensions.	S. Lancs. Dist.	15-6-25
Evans, L. E. J.	,,	Ministry of Pensions.	S. West Dist.	15-6-25
Horrocks, W. J.	,,	Ministry of Pensions.	S. Lancs. Dist.	16-6-25
Wills, N. T.	,,	Ministry of Pensions.	S. Lancs. Dist.	16-6-25
Greensmith, F. G.	,,	Ministry of Pensions.	N. Mid. Dist.	1-7-25
Cox, F.	,,	Savings Bank Dept.	S. Mid. Dist.	21-6-25
Eagland, S. V.	,,	Savings Bank Dept.	E.-in-C. Office.	1-7-25
Carpenter, W. G.	,,	Savings Bank Dept.	S. East. Dist.	1-7-25
Farrell, W.	,,	N. Mid. Dist.	E.-in-C. Office.	12-7-25
Laird, J. H.	,,	N. Wales Dist.	Sc. East. Dist.	1-7-25
Ashwell, G. H.	,,	N. Mid. Dist.	N. Dist.	23-8-25
Randall, F. W.	,,	S. West. Dist.	S. Wales Dist.	23-8-25
McHugh, C. J.	,,	S. Lancs. Dist.	Land Registry, Ireland.	1-9-25
Hale, R. E.	,,	London.	London Postal Service.	1-9-25

OTHER CHANGES.

Name.	Rank.	District.	Cause.	Date.
Few, H. P. ...	Higher Exec. Officer.	E.-in-C. Office.	Superannuation.	12-6-25
Parkinson, E. ...	Clerical Officer.	N. East. Dist.	Superannuation.	30-6-25
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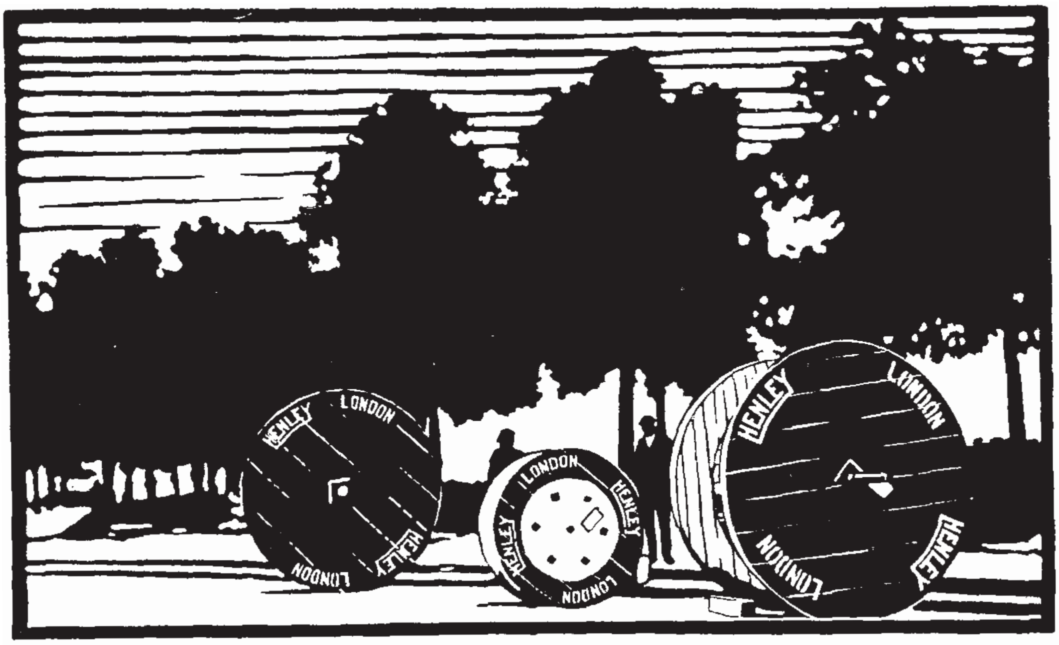

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PAGE
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Automatic Telephone Mfg. Co., Ltd. iii
British L.M. Ericsson Mfg. Co., Ltd. v
Creed & Co., Ltd. ... ... viii and ix
Henley's, W. T., Telegraph Works Co., Ltd. ... xi
I.P.O.E.E. Papers xiv
Johnson & Phillips, Ltd. xvi
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Pitman & Sons, Ltd. ii
Rentell S., & Co., Ltd. xii
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Errors in Part 3, Vol. XVIII., October, 1925, issue.

We regret that a number of errors crept into our last issue. Readers interested will perhaps amend their copies as follows :—

Corrections to article on
" Junctions working between Automatic and Manual Exchanges."

Page	231	GB should read GG.
Fig.	13	Relays (from left to right) should be labelled C, D and S.
,,	14	Relays (from left to right) should be labelled S, H, CO and A.
Page	238	Sixth line from bottom—LA should read LB.
,,	239	Number and title of Fig. 17 should be placed under second diagram on page 240.
,,	240	Number and title of Fig. 19 should be placed under diagram on page 239.
,,	241	First diagram should be labelled Fig. 22—" Magneto and C.B.S. No. 1 Exs. Dial Key per Junction."
,,	241	Second diagram should be labelled Fig. 23—" C.B.S. No. 1 Exs. Outgoing ; Loop or battery dialling or outgoing portion of bothway, battery dialling."
,,	242	First diagram should be labelled Fig. 20—" Non Mult. Magneto Exs., Outgoing loop or battery dialling or outgoing portion of bothway, battery dialling."
,,	242	Second diagram should be labelled Fig. 21—" Non Mult. Magneto Exs., outgoing portion of Bothway—Loop dialling."
,,	242-3	Delete references to C.B.S. No. 3 Exchanges.
,,	243	Fig. 25. Relay marked E should be D ; Relay A should be L ; Relay C should be CO.
,,	244	Fig. 26. Relay D should be S_1 Top Jack and lamp should be No. 2. Bottom ,, ,, ,, ,, ,, No. 1.
,,	245	Fig. 27. Relay C.L. should be F. ,, D.D. ,, ,, M. ,, D ,, ,, S.
,,	246	Fig. 29. Relay D ,, ,, S. ,, D.D. ,, ,, M.
,,	246	Last line, springs 11 and 9 should read 10 and 9.
,,	,,	Third last line, comma after D.M.

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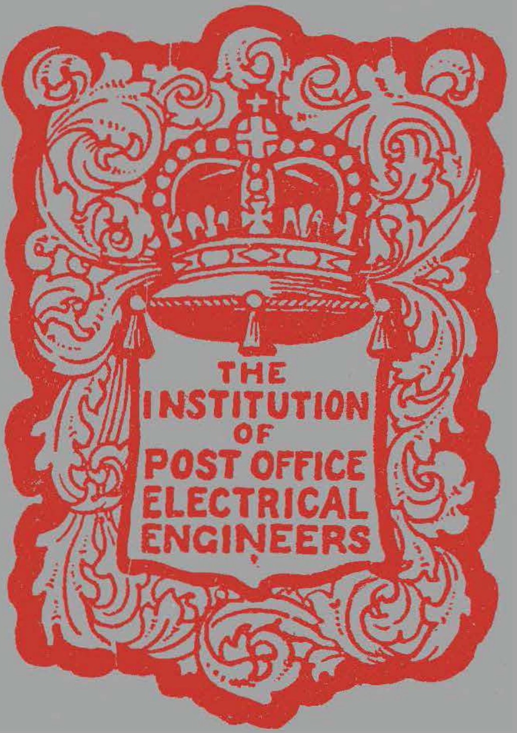

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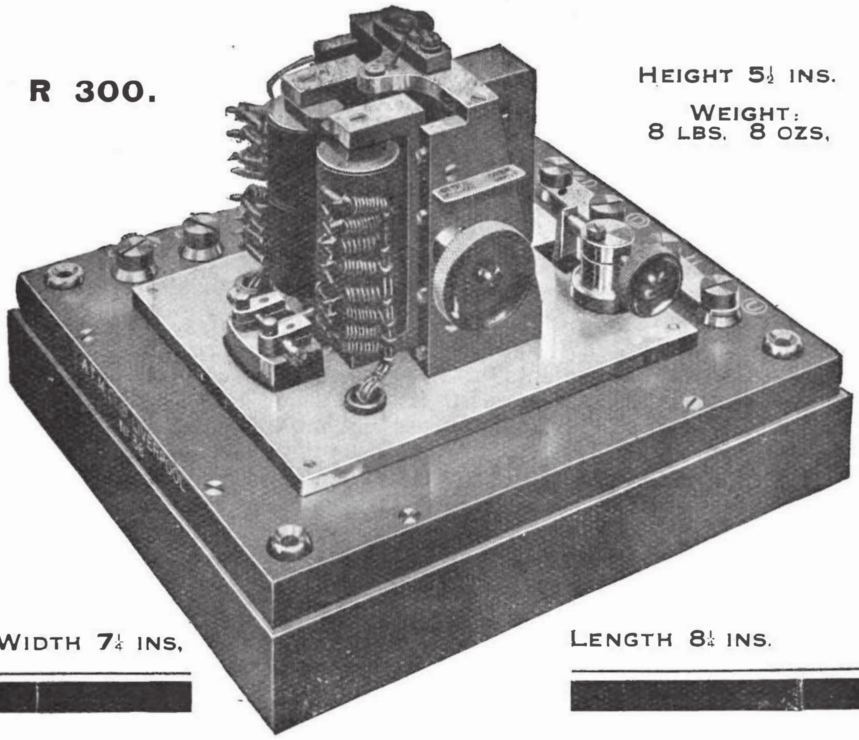

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CONTENTS FOR JANUARY, 1926.

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PAGE

THE POST OFFICE AND AUTOMATIC TELEPHONES 321

THE ALDEBURGH TELEPHONE REPEATER STATION—R. J. Nunn, A.M.I.E.E. 352

POST OFFICE SERVICES: PROVISION OF INCREASED PUBLIC FACILITIES BY MEANS OF KIOSKS—F. McClarence, A.M.I.E.E. ... 358

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM ... 362

EMPLOYMENT OF PNEUMATIC DIGGING AND ROCK BORING TOOLS ON AERIAL LINE CONSTRUCTION—Major H. Carter, A.R.C.Sc., B.Sc., A.M.I.E.E. 363

TWO INTERNATIONAL CONFERENCES AND THE INDUCTIVE INTERFERENCE PROBLEM—S. C. Bartholomew, M.I.E.E. 370

THE THEORY OF LADDER NETWORKS 381

NOTES AND COMMENTS 385

CORRESPONDENCE 391

HEADQUARTERS NOTES 395

LONDON DISTRICT NOTES 399

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS ... 402

LOCAL CENTRE NOTES 405

BOOK REVIEWS 415

STAFF CHANGES 421

COMMUNICATIONS 424

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS ... 424

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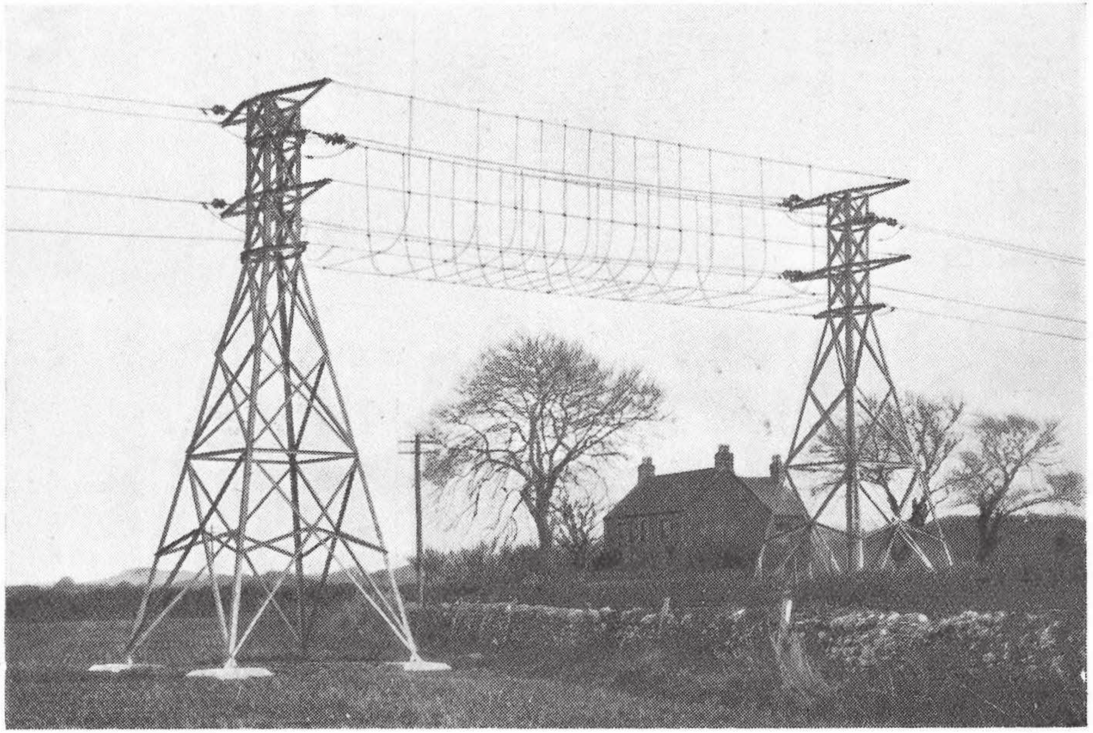

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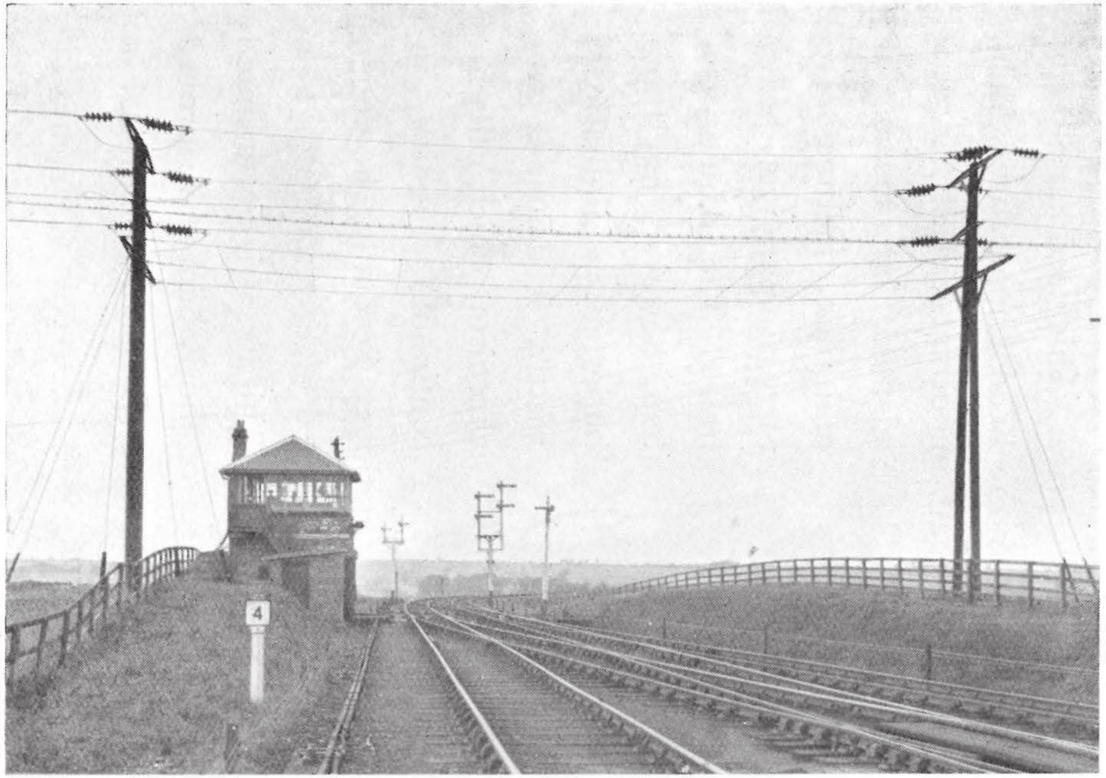


66,000-volt, Overhead Transmission Line, with duplicate strain insulators and lace guard crossing a railway track.

Erected for the Newcastle-on-Tyne Electric Supply Co., Ltd.

SIEMENS BROTHERS & CO., LIMITED, WOOLWICH, LONDON, S.E. 18.

The Creed Start-Stop

The Creed Start-stop System was designed with the object of securing a telegraph machine that will work well at all speeds and under all telegraph conditions, and which can at the same time be produced at a moderate price. This need has already been met to a certain extent by the Baudot apparatus, which, while working well on the least important circuits, is also adapted by means of multiplex methods, to carry comparatively heavy traffic. The Baudot system, however, has three important limitations. Firstly, it demands synchronism, which calls for continuous running in more or less small and isolated stations. Secondly, the design of the Baudot printer limits the speed of each operator to a maximum of 30 words per minute. Thirdly, it is not adapted to page printing. These features of the Baudot have proved a serious obstacle to its general use. It is not economical in first cost, in staff or in running costs.

Write for particulars to

CREED & CO., LTD.,

Telegrams : "Credo, Croydon."

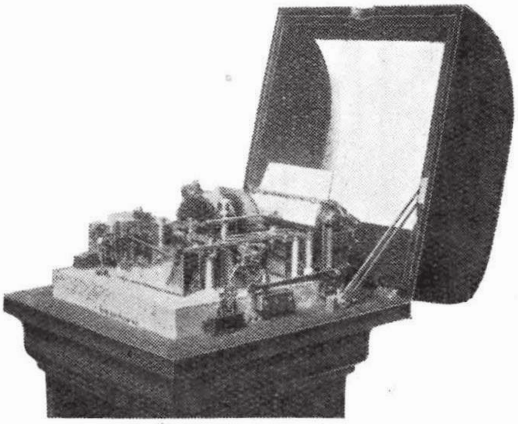
Telegraph System.

The CREED START-STOP SYSTEM meets the following conditions :—

1. *Simplicity of design* enabling the ordinary mechanic to understand and maintain it.

2. *Inter-changeability of Machines and Parts* of machines, making it possible for any machine or part of a machine to be quietly and easily removed and any other machine or part to be put into its place.

3. *Ease, convenience and uniformity of operation and adjustment*, enabling the ordinary operator to understand and work any and every machine in the service. This is very important from the point of view of the training and maintaining the staff.



4. *Durability and Reliability*, without which no machine can be satisfactory.

5. *Flexibility as to speed*, enabling it to work at low or high speeds as desired.

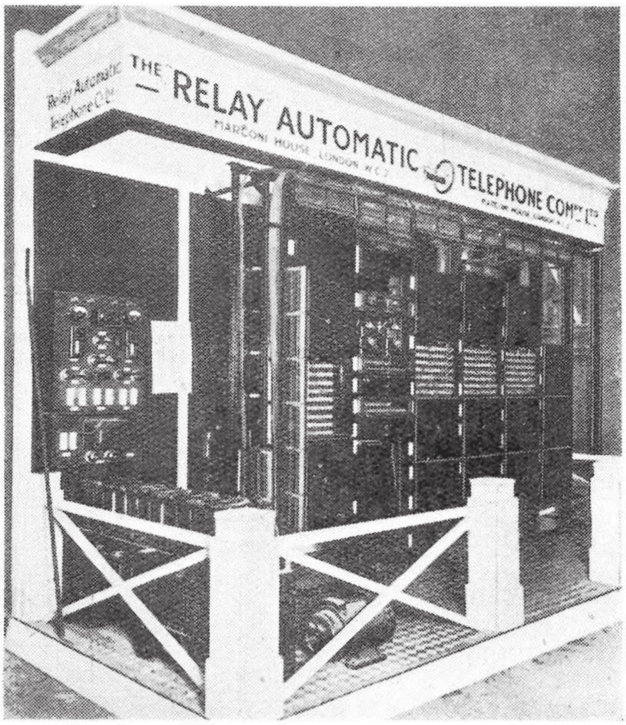
6. *Low Cost*, so as to warrant its use on very lightly-loaded circuits.

CROYDON, ENGLAND

Telephone : Croydon 2121

RELAY

AUTOMATIC TELEPHONES


THE RELAY AUTOMATIC TELEPHONE COMPY LTD.
MARCONI HOUSE, LONDON, W.C.2.
Relay Automatic Telephone Co. Ltd.

The Relay Automatic Telephone Exchange which linked up every part of the great Wembley Exhibition

Wembley's Tribute

The following letter is from Lieut.-General Sir Travers Clarke, K.C.B., K.C.M.G., the Director General of the British Empire Exhibition :—

"AT the close of the 1925 season of the British Empire Exhibition, I wish to express to you my sense of appreciation of the satisfactory work done by the Relay Automatic Telephone Company system at Wembley Park during 1924 and 1925.

The system, which has been employed for communication in the Administrative Offices and throughout the grounds, has worked very well and has been a great aid to the staff in carrying out their work.

It was satisfactory to note that British engineering enterprise had coped so well with the problem of Automatic Telephone communication."

RELAY FEATURES

Day and night service—Secret, only two wires to each telephone.

No mechanical switches—no oiling nor cleaning, cannot wear out, minimum maintenance.

System built entirely with relays, having a maximum movement of 1/32"; ample contact pressure renders it immune from troubles due to dust, heat, vibration, etc.

Voltage only 24—System is practically silent and motionless.

Write for Booklet No. 9.

THE RELAY AUTOMATIC TELEPHONE CO., LTD.,
Marconi House,
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BRITISH GOODS ARE BEST

THE
Post Office Electrical Engineers' Journal

THE POST OFFICE AND AUTOMATIC TELEPHONES.

Summary of a paper read by Col. T. F. Purves, O.B.E., before the Institution of Electrical Engineers.

" In the art and practice of telephony the development of means whereby one talking circuit can be connected, at will, with any other has always presented a leading problem, second only to those involved in the actual transmission of speech.

" Although its study has been accompanied by a large amount of invention, it is essentially a problem in pure engineering. The object accomplished is one which, in itself, is simple, and the immense amount of effort and ingenuity which has been expended upon it by many hundreds of engineers has been directed wholly to securing its accomplishment at minimum cost in money and time.

" The various systems of switching classed as ' Automatic ' perform no new function in telephony; rather do they represent the culmination of a continuous process, in which electrical and mechanical devices have been increasingly utilised in order to reduce the amount of human effort required to place a telephone subscriber in communication with the correspondent with whom he desires to speak. In this economy of effort the subscriber has shared, and in modern ' manual ' switching systems the only manipulative act required of him is that he should lift the telephone receiver from its rest before speaking, and replace it when he has finished.

" The adoption of the automatic system represents a reversal of this policy of economy of operation, so far as the subscriber is concerned, since it throws upon him the whole of the manipulation required to effect the ordinary local calls which generally constitute the bulk of his transactions, and for that reason the introduction of automatic exchanges in any telephone area is generally a matter of considerable public interest.

" The desire of the general public for information is catered for by the daily Press, and, at the other extreme, the professional telephone engineer has at his disposal a great mass of technical literature in many forms, in the multitudinous details of which the electrical engineer who is interested in only a general way may be pardoned for sometimes complaining that he ' cannot see the wood for trees.' I shall therefore endeavour to give a general description of the function of automatic switching apparatus in telephony, with a few main details of the most recent innovations incorporated in the system which is now being installed in new exchanges in London."

The paper described the operation of ordinary Strowger step by step mechanism and detailed the functions to be performed and also gave particulars of the development of Strowger automatic equipment in this country from 1912, detailing the circumstances in which decisions are given for the introduction of automatic equipment when manual exchanges fall due for replacement. The decisions have been given as a result of financial comparative studies and it has been found that the economy of providing automatic or manual equipment could in many cases be determined without detailed individual calculation by the application of the following general principles :—

" (1) In an area where the anticipated development on all exchanges in a period of 20 years does not exceed 1000 subscribers' lines, manual equipment is to be provided.

" (2) In all other cases automatic equipment is to be installed, provided that the following traffic conditions obtain :—

(*a*) The ' calling rate ' to average not less than 1.2 calls per subscriber in the busy hour of the day.

(*b*) The proportion of local traffic to be not less than 70 per cent.

(*c*) The number of manual operators' positions required, in association with the automatic exchange, not to exceed 55 per cent. of the number of positions required for a manual system.

The fulfilment of conditions (*a*), (*b*) and (*c*) provides a safe case for the adoption of the automatic system. Cases which fail to satisfy these conditions are treated as border-line cases and are subjected to detailed calculation. The result of the investigation of these doubtful cases has, so far, shown that in more than 80 per cent. of them the automatic system represents an economy."

" Experience has shown that there are few areas where the 10 years development will reach or exceed 2000 subscribers' lines in which the automatic system will not show a comparative saving and as a result it recently was decided that it is safe to install the automatic system without detailed financial comparisons with manual if the following conditions will be satisfied within that period :—

(1) The average subscriber's calling rate to be not less than 5 calls per day.

(2) The number of local calls switched automatically to be not less than 4000 per day.

(3) The proportion of originated calls requiring to be handled manually to be not more than 40 per cent.

" On the other hand, if the number of local calls which might be switched automatically will not exceed 3000 per day within the 10 years period, manual equipment will be installed without question.

" The introduction of the automatic system does not necessarily involve any appreciable modification of the private branch exchange switchboards working in the area. A great many private automatic exchanges have nevertheless been installed by the Post Office to meet the wishes of its subscribers. Some of these exchanges provide for over 500 lines. The majority of them are of the Relay Automatic Telephone Co.'s type."

The paper dealt in detail with the studies that are undertaken to deal with the comparative financial position as affecting the positions of exchanges and the lay-out of external plant. An important consideration is the fact that with a manual system 10,000 line units are in general use, but when changing a system over to automatic working, the general geographical lay-out of the area may be such as to encourage the adoption of smaller units leading to shorter average subscribers' lines of light copper, thus reducing the subscribers' copper costs at the expense of somewhat increased cost in the junction lines. Fig. **1** illustrates this principle in a case where the economical size for exchange units will be 2,000 lines assuming a density of 1,500.

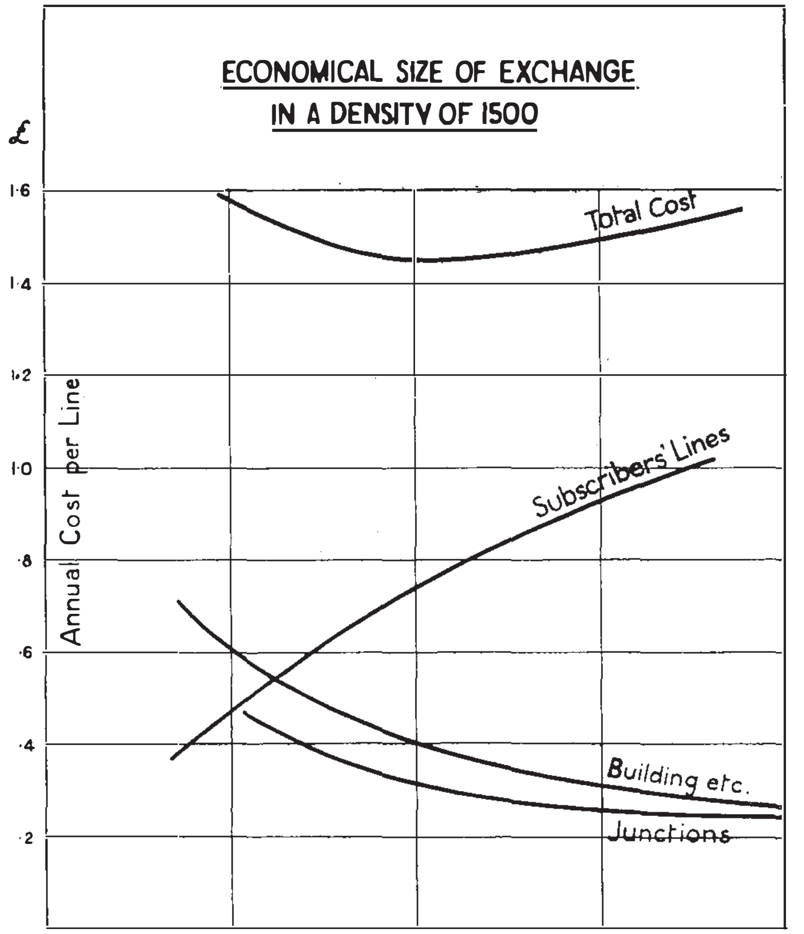
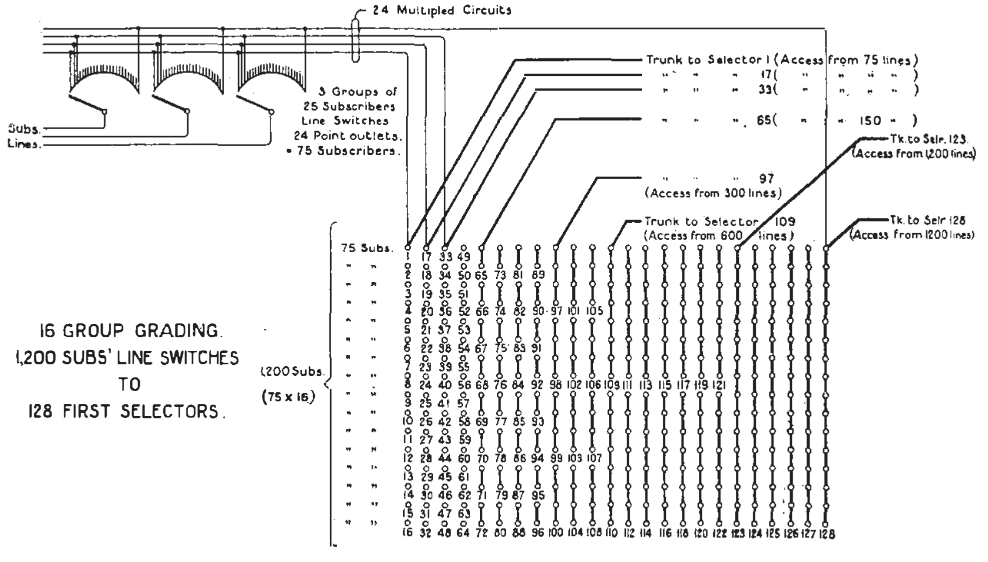


FIG. **1**.

As regards the lay-out of internal plant, attention was drawn to the adoption by the Post Office of the system of grading between the banks of one rank of switches and the wipers of the next rank. Fig. **2** shows the case of grading between 24 point line switches and first selectors. Assuming the standard grade of service to be 1 in 500, it has been found that the average traffic per switch would be as indicated in the following extract from the paper:—


24 Multipled Circuits
Subs. Lines.
3 Groups of 25 Subscribers Line Switches 24 Point outlets. = 75 Subscribers.
Trunk to Selector 1 (Access from 75 lines)
17
33
65 (Access from 150)
Tk. to Selr. 123 (Access from 1200 lines)
97 (Access from 300 lines)
Trunk to Selector 109 (Access from 600 lines)
Tk. to Selr 128 (Access from 1200 lines)
75 Subs.
1200 Subs. (75 x 16)
16 GROUP GRADING.
1,200 SUBS' LINE SWITCHES
TO
128 FIRST SELECTORS.

Link Frame. Grading Line Switch Outlets to Brushes of First Selectors.

FIG. **2**.

"As an illustration of the way in which the fluctuations of traffic are proportionately reduced as the size of a group increases, it may be of interest to consider the case of a number of subscribers each making two calls per busy hour with a holding time of 3 minutes. If these are arranged in a group of 10 having a common outlet, the resulting traffic would be equivalent to 1 traffic unit, and if the calls were made at absolutely uniform intervals they would all be carried by a single switching channel, continuously occupied. Similarly, a group of 250 lines would originate 25 traffic units and require 25 switching channels under the same conditions.

"Actually, if this provision were made the following percentages of calls would be lost:—

	Per cent.
For 10 lines (1 traffic unit and 1 switch) the loss would be	50
For 100 lines (10 traffic units and 10 switches) the loss would be	21.5
For 250 lines (25 traffic units and 25 switches) the loss would be	15
For 1000 lines (100 traffic units and 100 switches) the loss would be ...	7.6

"The matter may be looked at in another way as follows: Assuming that the standard grade of service of 1 in 500 is given, it is found that the average traffic per switch for the numbers of switches quoted above and in two graded cases would be as follows:—

10 Switches will be asked to carry 3.43 traffic units per hour; average traffic units per switch	0.343
25 Switches will be asked to carry 13.76 traffic units per hour; average traffic units per switch	0.55
100 Switches will be asked to carry 76.4 traffic units per hour; average traffic units per switch	0.764

100 Switches (10-contact grading), 43.6 traffic units per hour; average traffic units per switch	0.436
100 Switches (25-contact grading), 64.08 traffic units per hour; average traffic units per switch	0.641

" In the first three cases the preselectors finding their outlets *via* these switches are assumed to have a sufficient number of contacts to secure full availability in the two last (graded) cases the preselectors would have only 10 and 25 contacts respectively."

" SERVICES RESERVED FOR MANUAL OPERATION.

" The conversion of an area to automatic working does not involve the complete elimination of the manual operator. Some classes of traffic can at present be handled more conveniently and economically by manual than by automatic means and, in general practice, all calls for which more than the unit fee is charged will be dealt with by an operator who will record each call on a ticket in order that the proper debit may be made to the calling subscriber. In the Post Office system, operators are retained for trunk and toll circuit calls, extra-fee junction calls, phonogram (*i.e.*, telegraph message) calls, call-office and coin-box station calls, and for ' inquiry ' and ' information ' calls.

" Until recently all coin-box and call-office traffic was handled manually, but a new form of coin-collecting box has now been introduced which provides for the deposit of the local unit fee automatically. The attention of an operator will only be required for calls involving the deposit of additional coins in the box. The use of this new coin box in association with automatic systems will, in the first instance, be confined to provincial areas.

" For all calls to points outside the unit-fee area, the originating automatic subscriber dials a number which will obtain the attention of an operator in his own local exchange, or in the trunk or toll exchange, to whom he gives his demand. The call is then handled and recorded on a ticket in the regular manual fashion throughout.

" The method known as ' dialling out,' which permits the calling subscriber to obtain direct communication with an operator at the distant exchange required, is frequently advocated, but has not been adopted by the Post Office for extra-fee traffic, on account of the disadvantage of removing the supervision of such calls from the operator at the home exchange. The distant operator cannot conveniently be placed in a position to check the identity of the calling subscriber against whom the extra charge is to be debited.

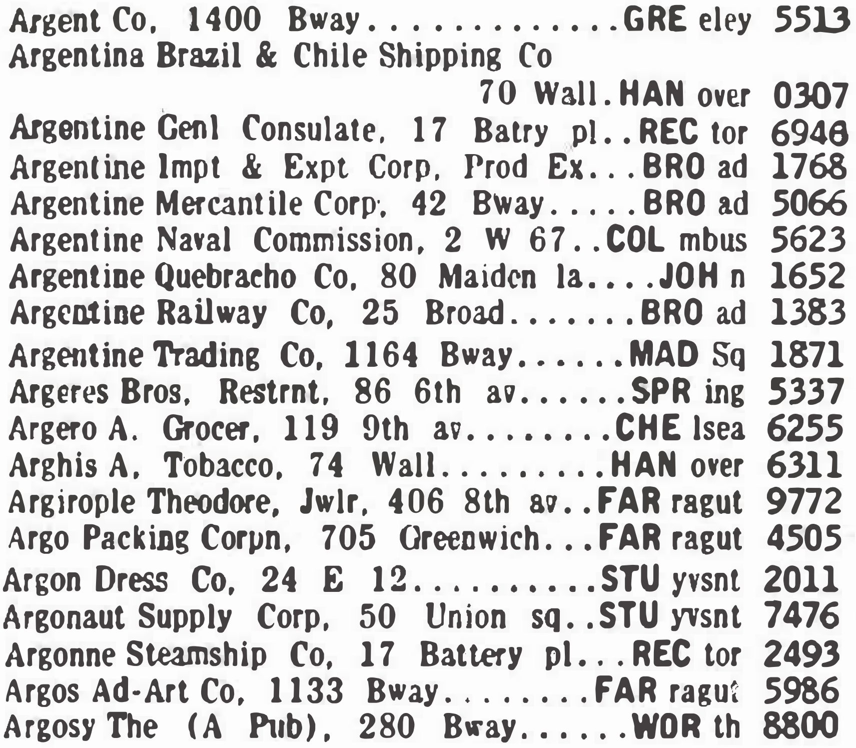
" The converse procedure of ' dialling in ' is, however, in common use. A subscriber on a manual exchange who requires a subscriber on an automatic exchange, reached by means of a junction or direct trunk line, makes the demand to his local operator as usual. This operator then completes the call by dialling from her cord circuit over the junction or trunk line directly into the switches at the automatic exchange, and thus sets up the desired connection without the intervention of an operator at the called exchange. This method of operating is adopted in all cases where line conditions permit, in preference to the alternative method of passing the demand verbally by order wire, or over a signalling junction to a manual operator at the required automatic exchange for completion.

" The character of the line has, however, a restrictive effect upon the extent to which ' dialling in ' can be employed. The method is practicable on almost any length of unloaded physical line, but the introduction of loading coils and repeaters and the use of phantom circuits give rise to certain difficulties. The trasmission constants of a loaded line introduce a marked degree of distortion in the dialled impulses, but in the few cases where this trouble would be sufficient to affect working efficiency it would be possible to remove the difficulty by the use of special methods and apparatus.

" Repeaters and phantom circuits are, however, obstacles which have not yet been fully overcome. A solution has been found to the cognate problem of sending calling and supervisory signals over such circuits, and considerable progress has been made with the solution of the dialling problem. A method which promises a satisfactory result involves the use of high-frequency alternating currents, the application of which to the line at the sending end is controlled by the dial impulses. At the receiving end, these trains of high-frequency alternations operate on the grid of a valve having in its plate circuit a relay which, in turn, controls the stepping relay of the selector switch.

" In ordinary local areas of medium size an endeavour is always made to change over from manual to automatic working simultaneously at all the exchanges in the area, but this is often impracticable, and in such cases one or more exchanges remain manual whilst the remainder are automatic. Under such conditions the methods of ' dialling in ' and ' dialling out ' are both adopted for interchange of traffic between the two systems, and each call is dealt with by one operator only.

" There is no objection to allowing an automatic subscriber to dial out to the operator at a manual exchange in the case of unit-free traffic, since the registration of the call is automatic and the operator, who has no extra charges to record, is not concerned with identity of the calling subscriber."

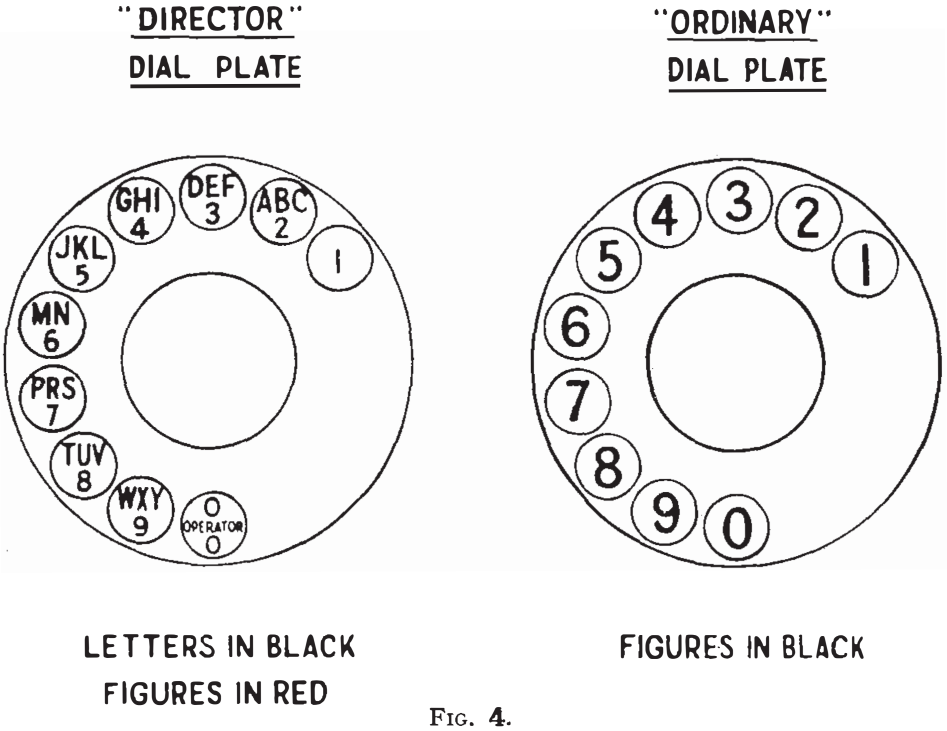


Argent Co, 1400 Bway	GRE eley	5513
Argentina Brazil & Chile Shipping Co 70 Wall	HAN over	0307
Argentine Genl Consulate, 17 Batry pl	REC tor	6948
Argentine Impt & Expt Corp, Prod Ex	BRO ad	1768
Argentine Mercantile Corp, 42 Bway	BRO ad	5066
Argentine Naval Commission, 2 W 67	COL mbus	5623
Argentine Quebracho Co, 80 Maiden la	JOH n	1652
Argentine Railway Co, 25 Broad	BRO ad	1383
Argentine Trading Co, 1164 Bway	MAD Sq	1871
Argeres Bros, Restrnt, 86 6th av	SPR ing	5337
Argero A. Grocer, 119 9th av	CHE lsea	6255
Arghis A, Tobacco, 74 Wall	HAN over	6311
Argirople Theodore, Jwlr, 406 8th av	FAR ragut	9772
Argo Packing Corpn, 705 Greenwich	FAR ragut	4505
Argon Dress Co, 24 E 12	STU yvsnt	2011
Argonaut Supply Corp, 50 Union sq	STU yvsnt	7476
Argonne Steamship Co, 17 Battery pl	REC tor	2493
Argos Ad-Art Co, 1133 Bway	FAR ragut	5986
Argosy The (A Pub), 280 Bway	WOR th	8800

FIG. 3.

The main interest in the paper, however, lies in the Author's description of the proposals that have been made for the operation of very large areas such as London, Glasgow, Liverpool, Manchester and Birmingham. The system is to be somewhat similar to that adopted by the Bell Telephone Companies in the large cities of America, where the W.E.Co.'s panel system has been adopted. This involves the introduction of a special directory in which the subscribers' exchange particulars are specially printed—vide Fig. 3, which is an extract from the New York Telephone Directory.

The object in printing the directory in this manner is to enable a single directory to serve for both manual and automatic service, using for the latter purpose a dial with special number plate, as per Fig. **4**, where the new or director type is compared with the ordinary dial plate. The automatic subscriber is required to dial the first three letters of the exchange name followed by the four figure number. A modification of the step by step system necessary to permit of this being done economically is embodied in what is known as the Director System, and the following extract from the paper will make the subject clear:—


"DIRECTOR" DIAL PLATE

"ORDINARY" DIAL PLATE

LETTERS IN BLACK FIGURES IN RED

FIGURES IN BLACK

Fig. **4**.

" The Choice of a System for London.

" Four years ago the development of the ' panel ' system had reached a stage which placed it far in advance of other then existing systems in respect of suitability for the equipment of the largest cities. The Post Office was eager to start the introduction of automatics in London, as many large new exchanges were required to provide for development and for the replacement of existing obsolescent or inadequate exchanges, and the installation of these important exchanges on the manual system would have had the effect of postponing by many years the ultimate complete conversion of the area to automatic working. The panel system was, therefore, very closely studied and the opinion reached was so favourable that it was decided to proceed as rapidly as possible with the preliminary arrangements for its adoption. It was admittedly both costly and complex; much design and engineering work still remained to be done before it could be said to have reached a state of comparative finality, and many of its features, which had been developed to meet the telephonic conditions of to-day in New York, could not without modification be applied to the very different conditions of London. On the other hand it was obviously a system of unbounded possibilities and no one doubted that it could be made to meet any legitimate service requirement that might arise. A factor not to be overlooked was that it had behind it the high prestige of the American Bell System, which had staked very large financial commitments on its success, and whose able engineers would, for years to come, continue to strain every effort to bring it to perfection.

" Plans were prepared for a first panel exchange in London, to be known as ' Blackfriars,' and at the same time the Post Office started to negotiate an agreement with the Western Electric Co., in accordance with which the manufacture of panel equipment would have been commenced in England under conditions that would ultimately have permitted other British telephone manufacturers to obtain a share of the work. While these arrangements were proceeding, the sponsors of step-by-step automatic systems had not been idle or asleep, and early in 1922 the Automatic Telephone Manufacturing Co. called our attention to a notable development of the Strowger system by the Automatic Electric Co., of Chicago, who had succeeded in devising and combining with the step-by-step system a call-storing and translating scheme, which had endowed that system with practically the same elements of numbering and trunking flexibility that had first been conceived in association with the panel system. To this new development the name ' Director System ' was given. The matter was, naturally, one of first-class interest and, although the immediate proposals were in a somewhat embryonic stage, they were at once investigated very fully.

" In association with the Automatic Telephone Manufacturing Co.'s engineers, a miniature multi-exchange system was laid out in such a way as to cover as far as possible all the different types of service required and exchange conditions met with in London, and was installed at the General Post Office as a working model of the director system. (A similar working model formed part of the Post Office exhibit at the British Empire Exhibition at Wembley.) Exhaustive study and trial led to the conclusion that the director system contained all the essentials required as a basis on which to frame a complete equipment of circuits and apparatus admirably fitted for the service of such an area as London, and it was evident that a practicable alternative to the adoption of the panel system had become available. In November 1922 I definitely recommended the adoption of the step-by-step system, with the addition of the ' director.' The main reasons on which that decision was based may be of interest, and are as follows :—

(1) The first cost of director exchanges was somewhat lower than the probable cost of the panel system manufactured in England.

(2) The fundamental electrical plan of the system is very much simpler than that of the panel. Circuits for particular purposes are easier to design and easier to understand.

(3) The Post Office engineering staff was already familiar with step-by-step systems, and it had been found that men could readily be trained to undertake all the duties of maintenance. The difficulties involved in securing and intensively training the requisite staff for handling the panel system—on the large scale of the necessary programme—would certainly have been considerable, and might have involved serious delay.

(4) The apparatus to be employed in the director system was all of existing types which had stood the test of years of actual use, and which could be depended upon to give first-class service. The scheme was purely one of new electrical circuits and combinations. It was possible, even at that early stage, to visualize the lines on which circuits for all purposes might be designed and, in fact, to see right through the eventual London system to a far greater extent than was possible in the case of panel equipment.

(5) The director system applied readily and naturally to small, as well as to large, exchanges and to ' satellite ' * exchanges as well as to main

---

* A "satellite" exchange is one provided only with subscribers' line switches and local selectors, and dependent upon an adjacent main exchange for all manual services and for the routing and handling of all its external traffic.

exchanges. The panel system had not been developed with a view to serving small or satellite exchanges. The fact that it could be made to do so was not doubted, but it did not appear that the solution was likely to be an economical one. This would be a matter of little importance in New York where the dense population of its large business buildings and apartment houses, combined with its high percentage of telephone development, necessitates that nearly all exchanges must have a capacity approaching 10,000 lines. In the 'down-town' area of New York many of the exchange buildings will have capacity for four or more exchange units of 10,000 lines each. In widespread and less opulent London there have to be very many small exchanges and satellite exchanges, and it is essential to have a system which can be applied economically to such conditions. It is estimated that in 10 or 12 years' time there will be at least 130 separate exchanges in the London area. Of these not more than about 50 will be in the business districts of the City and West End, and of this number only about 30 will have an ultimate capacity of 10,000 lines, while about 20 will be limited to 5,000 lines. The remaining 80 exchanges in the area will include about 50 of 3,000 lines, 20 of 2,000 lines, and 10 of 1,000 lines. (In several cases two or three exchange units of 10,000 lines each will be accommodated in the same building.)

(6) The Post Office was already committed to several variations of the step-by-step system on a considerable scale in the provinces. The possibility of using the same system in London replaced the somewhat dismal prospect of adding another and very complex system to the rather divergent group already established, by the much more attractive prospect of being able to standardize a type of automatic system for general use throughout the country. As a direct result of the adoption of the director system, a large measure of standardization has since been accomplished, as referred to later. It will in future be possible to move staff from one district to another as may be necessary, without confronting the transferred men with unknown types of apparatus and circuits in the exchanges.

(7) Prior to the adoption of the director system, it had been ascertained that arrangements could be made for spreading the work among the regular exchange contractors of the Post Office at an early date. The important question of supply was thus greatly eased, as existing British factories became at once available for production purposes. The necessity for placing even the initial orders abroad was avoided, and the Post Office was able to enlist the co-operation of the skilled engineering staffs of all the contractors who had been producers of step-by-step equipment.

" The negotiations in hand for the introduction of the panel system were therefore broken off and agreements were entered into with the Automatic Telephone Manufacturing Co. for the supply of director switching equipment for the equivalent of about 55,000 exchange lines, and with the Western Electric Co., Messrs. Siemens Brothers and the General Electric Co. for smaller quantities. Provision is made for existing patents, and for future patents during a specified period, to be pooled on terms which will enable the Post Office to call upon all the firms to install plant covered by patents in the possession of any of them. At the end of the period of about three years covered by the contracts it will also be possible to utilize the services of other competent firms who may desire to take up the manufacture of step-by-step automatic equipment. These agreements cleared the way for standardization of system, and before proceeding to specify circuits and layout a very careful comparative study was made of the characteristics of the systems identified with each of the firms named, of all of which the Post Office had had practical experience.

" Subsequent to the decision to adopt the director system, the firm of Siemens Brothers had submitted analogous developments styled the 'translator' and the

' by-path ' systems, applicable to its type of step-by-step equipment, and at a later stage the General Electric Co. also brought forward a proposal to embody in its system an equipment of devices having the same object, which had been termed the ' controller ' system. The ' translator ' and the ' controller ' systems existed, for the most part, on paper, but they furnished interesting evidence of the readiness and flexibility with which the long-established step-by-step system lent itself to the grafting on of developments designed to achieve a newly conceived purpose.

" STANDARDISATION.

" It was recognised that the complete standardization of the automatic system for Post Office use could not be effected in a single step without long initial delay and the temporary paralysis of some of our sources of supply. The most pressing need was to secure that all future automatic exchanges should be of such design that they would be able to intercommunicate directly one with another, without requiring the addition of any special devices or circuit complications for the purpose. First attention was therefore given to the standardization of electrical circuits and operating currents for all inter-exchange purposes, and this has now been accomplished. Each contractor is allowed to supply plant of his own type of mechanical construction, but all types must be capable of operating in the prescribed manner on the circuits which represent, for the time being, the standard methods of fulfilling particular functions. It will therefore be possible to equip any area, large or small, with exchanges supplied by any contractors who may, from time to time, secure the orders for their installation. The subscribers' automatic telephone and calling dial, and the operating impulses sent therefrom, are rigidly standardized, and the same applies to all trains of operating impulses and controlling or signalling currents sent from one exchange to another. Much progress has also been made in the standardization of the circuits which are purely internal to an exchange and do not affect intercommunication with its neighbours. All our contractors are also encouraged to unify the details of the mechanical construction of their apparatus as much as possible, with a view to the gradual evolution of a fully standardized Post Office automatic system. Such standardization has, of course, nothing whatever to do with any ideas of finality or fixation of practice. It simply means that at any given moment there is one standard way of making or doing any given thing. Improvements emanating from any source can be studied and introduced, not in partial and possibly conflicting ways as in a divergent collection of systems, but on a systematic general basis which greatly facilitates effective progress.

" The first standardization study soon narrowed itself down to a choice among various important features in which the systems of the Automatic Telephone Manufacturing Co. and of Messrs. Siemens Brothers differed from each other. These features could not, as a rule, be considered independently; to a great extent the adoption of one dictates the adoption of one or more of the others. The decisions on the points at issue were as follows:—

(1) Impulses over junction circuits to be signalled round the loop, and not over one earthed conductor.

(2) Supervisory signals to manual exchanges and auto-manual positions to be sent by reversal of battery.

(3) Subscribers' talking and signalling current to be fed to the loop at final selectors, or at outgoing junction repeaters.

(4) Main battery to have E.M.F. of 50 volts (25 cells).

(5) Registration on subscribers' meters to be effected by means of a ' booster ' battery.

(6) Subscribers' lines to enter *via* 25-point rotary line switches having a ' home ' position and 24 outlets to selectors.

(7) The ' private ' banks on the levels of group selectors to have 11 points.

(8) The ' busy ' test on private bank contacts to be provided by an earth connection.

(9) Trunk-hunting switches to be stepped forward by individual, self-controlled drive.

" Six of these points (1, 2, 3, 4, 8 and 9) represent the established practice of the Automatic Telephone Manufacturing Co.

" With regard to point (5), the Department's experience with the Automatic Telephone Manufacturing Co.'s standard system of registration—by means of an electro-polarised relay operated by reversal of current when the called subscriber replies—indicates that, although accurate, it requires special testing and voltage-regulation plant to maintain it. For ' booster battery metering ' which has been adopted as preferable, the subscribers' meter, with the normal exchange voltage behind it, is wired to the ' private ' or test wire at the subscribers' rotary line switch. The meter is designed not to operate on this voltage. The ' test ' wire is linked up successively throughout all the switches used in a connection up to the final selector in the case of a local call, or to the outgoing circuit repeater in the case of a junction call. When the called subscriber replies, the operation of relays at the final selector or repeater applies a separate booster battery of 50 volts to the ' test ' wire in series with the main battery for about ½ second. The meter operates on this and its armature remains attracted on the normal battery voltage—the test wire being normally earthed at the final selector or repeater. It is confidently expected that this method will give complete immunity from false registration.

" It should be mentioned that in ' director ' areas a simpler method of operating the subscriber's meter is practicable and has been adopted. In such areas the first selector switch, which is next in the train of switches to the calling subscriber's rotary line switch and meter, contains a relay operated by the reply of the called subscriber. A separate conductor can therefore be provided, at little cost, between the two switches, enabling metering to be effected by the simple closure of the meter circuit when the called subscriber answers.

" The use of subscribers' rotary line switches with a ' home ' position—point (6)—is made necessary by the system of grading the outlets from the line switch banks to the first selectors. With graded outlets it is, of course, necessary that search over a level shall always start from the first outlet on that level.

" The use of an 11th contact on selector levels—point (7)—is dictated by the desire to obtain traffic overflow measurements on each working level.

" As soon as the leading characteristics of the general system had thus been determined the process of assimilating it to the director method of operation, and of designing the circuits and plant layout for all classes of service, began. For many months the engineers and traffic experts of the Post Office automatic group were engaged in almost daily discussions with the engineers of the four large contracting companies who are responsible for the manufacture and installation of the exchange plant. The matter involves the consideration of masses of meticulous technical details, and great numbers of proposals and devices have been suggested, considered, tried out, and accepted or rejected. This work is now complete, so far as the initial system is concerned. Equipment for several large exchanges is now in course of manufacture, and in the cases of the Holborn exchange and the mechanical tandem exchange the work of installation *in situ* has been commenced. It may be mentioned that it takes, under present conditions, about 6 months to plan the traffic and engineering details of a large automatic exchange, about 12 months to manufacture it, and a further 12 months, or more, to install it in position and tune up its circuits for service."

The application of the Director apparatus to the Strowger step by step system is indicated by the following extract from the paper :—

" The Automatic Electric Company's ' Director ' System.

" It has already been mentioned that the addition of the ' director ' to the long-established Strowger automatic system has endowed that system with facilities which enable any required connection to be set up by means of trains of controlling impulses having no necessary relationship with the impulses sent in from the calling dial of the originating subscriber.

" The function of the director is to receive and store the call in its original form, and to proceed to send it out into the exchange switching mechanism, translated into any trains of impulses which may be required by the existing layout of junction routes and switching centres, to steer the call through, link by link, to the line of the required subscriber. As soon as the required connection has been established, the director disconnects itself from the line and becomes available for other calls.

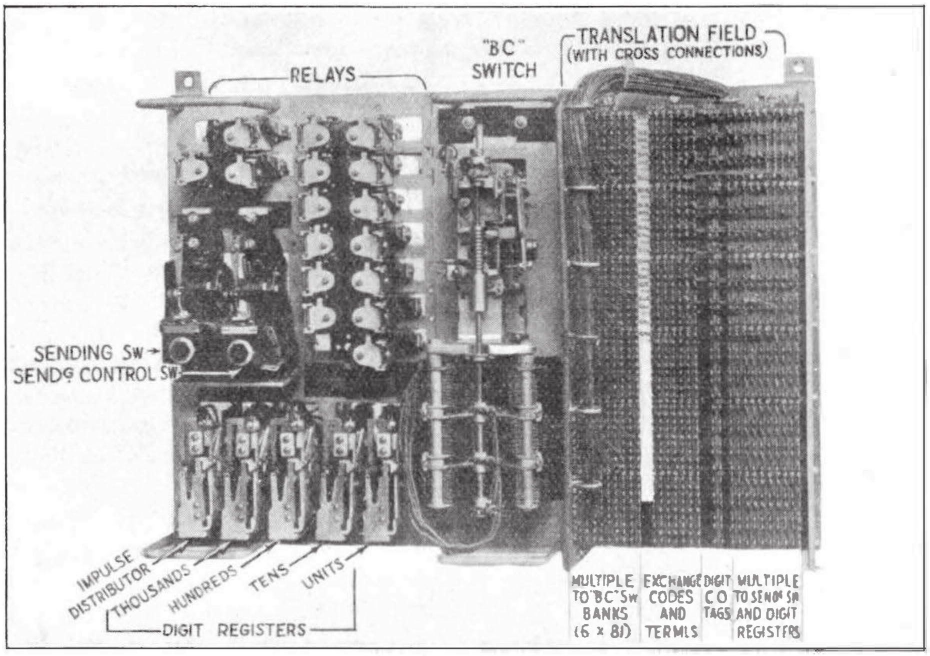

RELAYS
"BC" SWITCH
TRANSLATION FIELD (WITH CROSS CONNECTIONS)
SENDING SW
SENDG CONTROL SW
IMPULSE DISTRIBUTOR
THOUSANDS
HUNDREDS
TENS
UNITS
DIGIT REGISTERS
MULTIPLE TO "BC" SW BANKS (6 × 81)
EXCHANGE CODES AND TERMLS
DIGIT C.O TAGS
MULTIPLE TO SENDG SW AND DIGIT REGISTERS

Fig. 5.

" The London subscriber's calling dial will carry a combination of letters and digits similar to that already referred to in connection with the panel system, and the arrangement of exchange names and numbers in the telephone directory will also be identical with that adopted for the panel system.

" It should be noted here that the translation effected by the director applies not only to the number of impulses in a train but also to the number of trains sent. The subscriber will be required to signal 3 letters and 4 digits for each call, but the director can transform these 7 impulse trains into any number of directive trains from 5 to 10. This attainable maximum provides more than adequately for any possible future requirement of the London system, or any other system.

" The director consists of 9 switches with associated relays and a cross-connecting field. Two switches are of the usual Strowger type having vertical and horizontal movements; these are designated the ' A ' switch and ' BC ' switch respectively. Two switches are of the pre-selector type and are designated the ' sending switch ' and the ' sending control switch.' Five switches, designated ' minor switches,' are practically small Strowger switches with rotary movements only. Four of these switches are used as digit-storing registers and one as an impulse distributor.

" The ' A ' digit switches are grouped on separate racks and do not form part of the assembly of an individual director, which includes all the other pieces of apparatus mentioned, mounted on a rectangular frame measuring about 24 in. × 18 in. (see Fig. 5).

" The ' A ' digit switch receives the first train of impulses dialled by the subscribers, which corresponds to the first code letter of the exchange required. Each level of the ' A ' switch is associated with a separate group of directors set apart for effecting connections with exchanges having names commencing with the same, or an equivalent, letter, and the ' A ' switch, having been dialled to a particular level, searches to find the ' BC ' switch of a free director on that level.

" The second and third trains of dialled impulses are received by the ' BC ' switch; the second train lifts the switch brushes to one of the 10 levels, and the third train rotates the brushes to a particular set of contacts on that level. The ' BC ' switch is equipped with 6 brushes and 6 separate sets of bank contacts. Thus the dialling of the second and third of the three initial or ' code ' letters of the required exchange has set the ' BC ' switch of a director in a particular group to 6 particular multipled contacts, and has closed 6 circuits which will always be closed by any subscriber who dials that exchange code. The 6 circuits thus set up, when suitably cross-connected, enable the switches of the director to send out any desired number of trains of impulses from 1 to 6 (each train consisting of any number of impulses from 1 to 10) and so steer the call by its prescribed route to any required exchange, where the direct operation of the final 4 trains, representing the numerical digits of the dialled number, will reach the line of the called subscriber.

SKETCH TO ILLUSTRATE PRINCIPLES OF THE DIRECTOR SYSTEM.

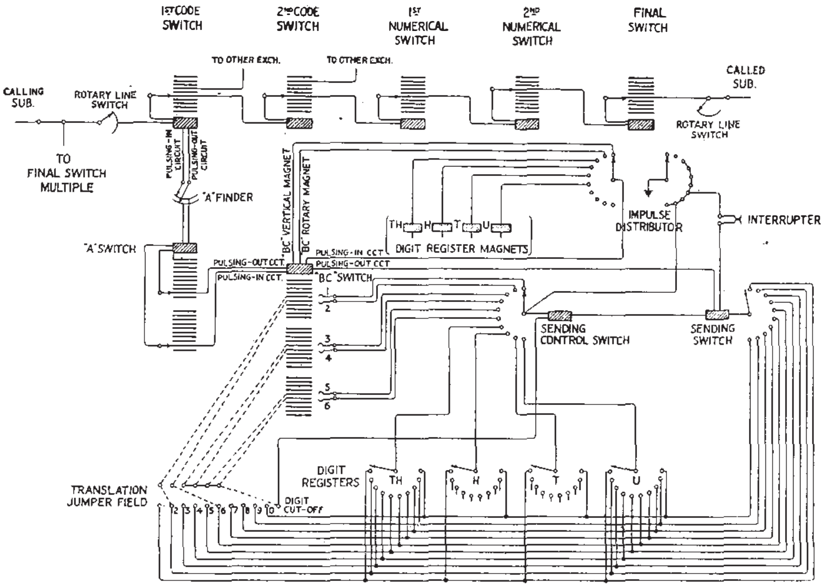


FIG. 6.

" It will be noticed that the initial letter of the exchange code—absorbed in the ' A ' digit switch—does not pass into the director and is not subjected to translation. It is found that the total quantity of apparatus required can be reduced by confining translation to the second and third code digits, and setting apart a group of directors to handle calls for the exchanges having initial letters with the same numerical equivalent. The first train of impulses is therefore used to select the level of the ' A ' switch which gives access to the appropriate group (ABC = level 2 ; DEF = level 3, etc.).

" The directors of each group are capable of serving 81 exchanges, and as 8 group levels are available on the ' A ' switch the total number of exchanges which could be served without mechanical modification of the directors is 648. This is so far above the number of exchanges ultimately required in London that the cross-connection field has been designed to serve 35 exchanges in each director group, or a total of 280. Even with this reduced number abundant spare space can be left, on the directors appropriated to each three initial letters, to avoid any restriction in the choice of exchange names on that account, although such restriction could easily be applied if necessary.

" Under average conditions a director to which properly graded access is provided will carry about 72 calls in the busy hour and will be occupied with each for about 20 seconds. To serve a busy city exchange the installation of from 150 to 180 directors is necessary.

" The operation of the director can be examined in more detail with the aid of Fig. **6**. The subscriber on lifting his receiver obtains, *via* the bank of his rotary line switch, a first code switch in the ordinary exchange system, and at the same time the ' A ' switch-finder hunts to find a free ' A ' switch, from which the subscriber receives the ' dial ' tone informing him that he may proceed to turn in the call. Suppose the subscriber wants the ' Avenue ' exchange and dials AVE 2468, which corresponds to 283 2468. The A is received by the ' A ' switch, the brushes of which are lifted to the second (or ABC) level, and a free ' BC ' switch in the group of directors associated with that level is found.

" The train of 8 impulses corresponding to V is dialled into the vertical magnet of the ' BC ' switch, *via* the impulse distributor, the two brushes of which are standing on the first pair of contacts. At the end of this train the impulse distributor takes one step, and the train of 3 impulses, corresponding to E, are received by the horizontal magnet of the ' BC ' switch. The six brushes of the ' BC ' switch are now set on the third contact of the eighth level in each bank. The impulse distributor brushes now step to its third pair of contacts.

" Dialling proceeds and the trains of dialled impulses representing the called subscriber's number are successively routed by the impulse distributor to the four digit registers which are set in the positions 2 on the thousands register, 4 on the hundreds register, 6 on the tens register and 8 on the units register. The call has now been received and stored in the director, but before this operation is complete the process of sending it forward in its transformed shape has already been begun.

" It may be assumed that direct junctions to the Avenue exchange can be reached through two ranks of code switches at the originating exchange and that the translation in the director required to set up these switches is to be ' 2, 6.' That is to say, only two trains of impulses are required, out of the possible six trains provided for, *via* the six brush circuits of the ' BC ' switch. If additional ranks of code switches at an intermediate switching centre had been involved, a correspondingly greater number of trains would have been necessary. The translation is effected by cross-connecting the first of the particular six bank contacts of the ' BC ' switch to contact No. 2 of the ' sending switch ' bank, and the second bank contact of the ' BC ' switch to contact No. 6 of the sending switch. The superfluous bank contacts (Nos. 3, 4, 5 and 6) of the ' BC ' switch will be connected to the ' sending control switch,' *via* the terminal marked ' D.C.O.' (digit cut-off), in order to step that switch to the correct position for discharging the digit registers at the proper moment.

" After the three code letters have been dialled in, the impulse distributor brushes will have moved to the third pair of contacts and the sending control switch will be standing on its first contact. The earth-connected brush of the impulse distributor will therefore complete a circuit, *via* brush 1 of the ' BC ' switch and the cross-connection, to contact No. 2 of the ' sending switch,' which will thus be earthed. At the same moment the earth-connected brush completes a circuit, permitting impulses from the interrupter springs of a continuously running impulse machine to be directed to the sending switch magnet, and the switch begins to step over its contacts. At each step an impulse is sent to the first code switch over the 'pulsing-out' circuit indicated in the figure. When the sending switch brush reaches its second contact, which has been 'marked' by the sending control switch, it encounters the earth connection and a relay is operated which prevents further impulses from being sent to the first code switch. The sending control switch now steps forward to the second 'BC' brush circuit and the sending switch returns to normal. Meantime the first code switch brushes have entered the second level of its bank contacts and found an outlet to a free second code switch.

"The sending control switch brush, now standing on its second contact, makes an earth connection, *via* brush circuit No. 2 of the 'BC' switch, with contact No. 6 of the sending switch. The sending switch again steps forward and now sends 6 impulses to the second code switch before its impulses are stopped by the earth on its contact No. 6. The second code switch brushes are stepped to level No. 6 and find a free line to the Avenue exchange, whilst the sending switch again returns to normal and the sending control switch steps to position No. 3. From this position it finds a circuit in turn, *via* brushes Nos. 3, 4, 5 and 6 of the 'BC' switch, which represent superfluous translation circuits and have all been joined, by a cross-connecting wire, to the 'digit cut-off' terminal. The brushes of the sending control switch are therefore carried straight forward to position No. 7. Positions No. 7, 8, 9 and 10 connect with the four 'digit registers' on which the Avenue number of the called subscriber has been stored. From these positions the switch will now successively control the sending of the thousands, hundreds, tens, and units digits. As these do not require translation the bank of the digit registers are multipled directly to the sending switch. The impulses for these digits are sent out over the junction line to Avenue and set up the numerical switches at that exchange. Immediately after the units digit has been sent out from the director the latter is released from the first code switch, all its parts return to normal, and the calling subscriber is connected through to the final numerical switch at Avenue, from which the required subscriber is being rung.

'The 'pulsing-in' circuit over which the subscriber's impulses pass into the director remains entirely separated, at the first code switch, from the 'pulsing-out' circuit over which the director passes forward the call through the code and numerical switches until the connection has been completely set up and the director has been dropped. Pulsing-out commences as soon as the exchange code portion of the number has been dialled in, *i.e.*, as soon as the impulse distributor reaches its third contact and connects earth to the sending control switch and to the interrupter of the impulse machine. The periods of storing the call and of sending it forward thus overlap each other and the actual delay in establishing connection with the called subscriber is, on the average, only about 2 seconds greater than it would be if the call were dialled straight into the switches.

"As a theoretical example of a more complex case of routing, involving the use of intermediate switching centres and the utilization of all the six available translation channels, it might be assumed that a call, say, from Ealing to Ilford, would be dealt with as follows:—The exchange code ILF (453) would have its second and third digits translated in the director to 234567. Digits 2 and 3 would operate first and second code selectors in Ealing, and gain access *via* an outgoing junction to a tandem selector in Holborn. Digits 4 and 5 would operate first and second tandem selectors in Holborn and reach a tandem selector in Maryland. Digits 6 and 7 would operate first and second tandem selectors in Maryland and reach a first numerical selector in Ilford. The four untranslated numerical digits of the subscriber's number would then follow and effect connection with the called line *via* the first and second numerical selector, and a final selector, at Ilford.

"The actual circuit arrangement of the director system is necessarily somewhat complex, and a discussion of it in any detail is not within the scope of this paper. (Mention should, however, be made of an innovation as regards the position of the battery feed to the calling subscribers. Hitherto on the Automatic Telephone Manufacturing Co.'s system this has always been located either at the final numerical switch or on the outgoing junction repeater. In the director system as adopted by the Post Office it will be located at the first code switch, thereby rendering outgoing junction repeaters unnecessary, except on tandem routes, and effecting a very appreciable economy in London and other large areas where the percentage of junction traffic is large.)

" Director Translations.

" Fig. 7 is a sketch of the arrangement of the translation jumper field. On the left of the drawing six sets of bank contacts each connected to a set of 81 terminals are indicated. Each of these six sets of terminals reproduces the bank contacts of the ' BC ' switch corresponding to each of the six brushes and is wired out to these terminals as indicated by the brush, or ' wiper,' numbers.

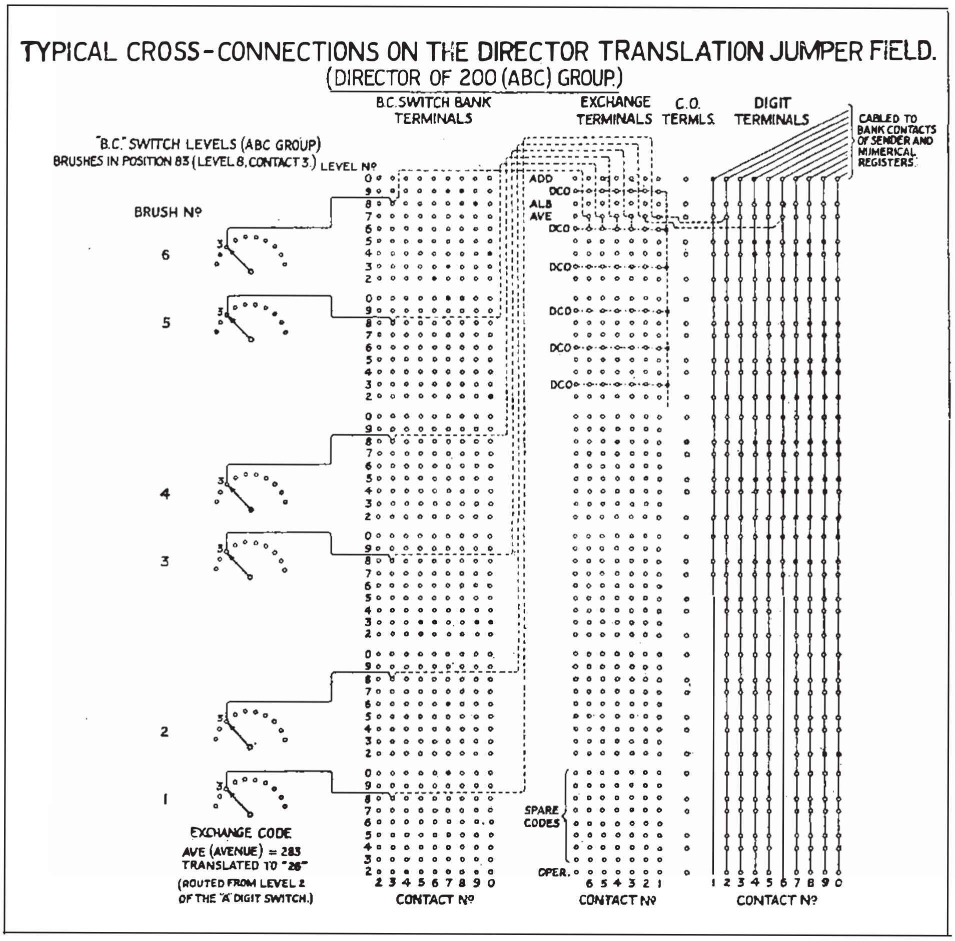

TYPICAL CROSS-CONNECTIONS ON THE DIRECTOR TRANSLATION JUMPER FIELD.
(DIRECTOR OF 200 (ABC) GROUP.)
B.C. SWITCH BANK TERMINALS
EXCHANGE TERMINALS
C.O. TERMLS.
DIGIT TERMINALS
CABLED TO BANK CONTACTS OF SENDER AND NUMERICAL REGISTERS.
"B.C." SWITCH LEVELS (ABC GROUP)
BRUSHES IN POSITION 83 (LEVEL 8, CONTACT 3.)
LEVEL Nº
BRUSH Nº
6
5
4
3
2
1
3
ADD
DCO
ALB
AVE
SPARE CODES
OPER.
EXCHANGE CODE
AVE (AVENUE) = 283
TRANSLATED TO "26"
(ROUTED FROM LEVEL 2 OF THE "A" DIGIT SWITCH.)
0 9 8 7 6 5 4 3 2
2 3 4 5 6 7 8 9 0
CONTACT Nº
6 5 4 3 2 1
CONTACT Nº
1 2 3 4 5 6 7 8 9 0
CONTACT Nº

Fig. 7.

" Levels 2 to 0 and contacts 2 to 0 on each level only are so wired out, level 1 and contact 1 being omitted since there are no letters equivalent to digit 1 on the lettered dial. At the centre of the assembly there are 35 sets of six exchange terminals, each set being labelled with an exchange name and wired to the tags representing the positions on which the six brushes rest when the code of that exchange has been dialled into the ' BC ' switch. Between every two sets of exchange terminals one set of D.C.O. (digit cut-off) terminals is fitted. On the right-hand side are 36 sets of digit terminals numbered 1 to 0, each vertical row of which represents one of the 10 bank contacts on the sending switch and digit registers.

" Cross-connections are made between the six exchange terminals and the 10 digit terminals as required to give the desired translation.

" The terminals marked ' CO ' are used for clearing the director when it is required to route a call by code translation only, without numerical digits. Certain service calls will be dealt with in this manner.

" The terminals marked ' OPER ' are used to route a call to an operator after the dialling of digit 0 by the subscriber. Such a call will find a director but will not operate the ' BC ' switch. A special relay, operated on 0 level calls only, is introduced into the director and sets up connections similar to a setting of the ' BC ' switch brushes, giving at once the desired translation. Arrangements are such that any predetermined director in any group can be reached from the 0 level of the ' A ' digit switch for this service.

" The various cross-connections used to give the different services required may be briefly summed up as follows :—

(1) *Subscriber to subscriber calls* (subscriber dials 3 code and 4 numerical symbols).

(*a*) *Translated to 1 code selection, followed by 4 numericals, e.g.*, if the subscriber dials ' AVE ' 1234, the ' AVE ' exchange terminals will be connected as follows :—

Terminal 1 will be jumpered to the digit terminal corresponding to the pulses required to be sent to the code selectors.

Terminals 2, 3, 4, 5 and 6 will be connected to the nearest ' D.C.O.' terminals.

The numerical digits will be repeated as dialled into the digit registers by the calling subscriber.

(*b*) *Translated to 2, 3, 4, or 5 code selections, followed by 4 numericals.*—The same method is followed as under (*a*), *i.e.*, exchange code terminals are jumpered to the digit terminals required. The unused exchange terminals are always connected to the nearest ' D.C.O.' terminals.

The numerical digits are repeated as dialled.

(*c*) *Translated to 6 code selections, followed by 4 numericals.*—The same method is followed as under (*a*), *i.e.*, exchange code terminals are jumpered to the digit terminals required. As all the exchange terminals are thus used, no connection to the ' D.C.O.' terminals is required.

(2) *Special service calls.*

(*a*) *Subscriber dials special service 3-letter code*, not followed by numericals, *e.g.*, TOL. The same method is followed as under 1 (*a*) or 1 (*b*), *i.e.*, the exchange code terminals are jumpered to the digit terminals necessary to route the call to the destination required. The first unused exchange terminal is jumpered to the nearest ' C.O.' terminal instead of the ' D.C.O.' terminal, and the remaining terminals are left disconnected.

(*b*) *Calls to operator* (*subscriber dials* ' 0 ').—The exchange terminals designated ' OPER ' are jumpered as described under 2 (*a*) above.

(3) *Vacant exchange codes.*

All vacant exchange code terminals associated with wiper 1 (only) are ' commoned ' and jumpered to the nearest ' SC,' *i.e.*, ' spare code ' terminal. The dialling of one of these dead exchange codes causes the director to be released immediately the third code digit is dialled, and the subscriber receives the ' number unobtainable ' tone signal.

" CALL INDICATOR WORKING.

" Until the conversion of London to automatic working is fully completed, which may occupy a period of from 15 to 20 years, manual working will exist side by side with automatic working and arrangements are necessary to ensure smooth operation between the two systems during the interim period.

" Traffic from automatic to manual exchanges will be handled by means of ' call indicator ' positions at the manual exchange, as illustrated in Fig. 8. The automatic subscriber will manipulate his calling dial in an identical manner for all calls. If the call be for a manual exchange the operation of the three initial letters of the exchange name will steer the call through to an available incoming junction operator's position at that exchange, and the further operation of the four numerical digits will cause the required subscriber's number to appear visually on a ' call indicator ' in front of the junction operator. This operator will, without speaking to the calling subscriber, connect the circuit manually to the required subscriber's line. She may use any one of her plugs and cords for this purpose ; the act of plugging into the subscriber's line jack brings into operation a ' cord trunk finder ' which connects the plug and cord to the junction upon which the displayed number has been pulsed.

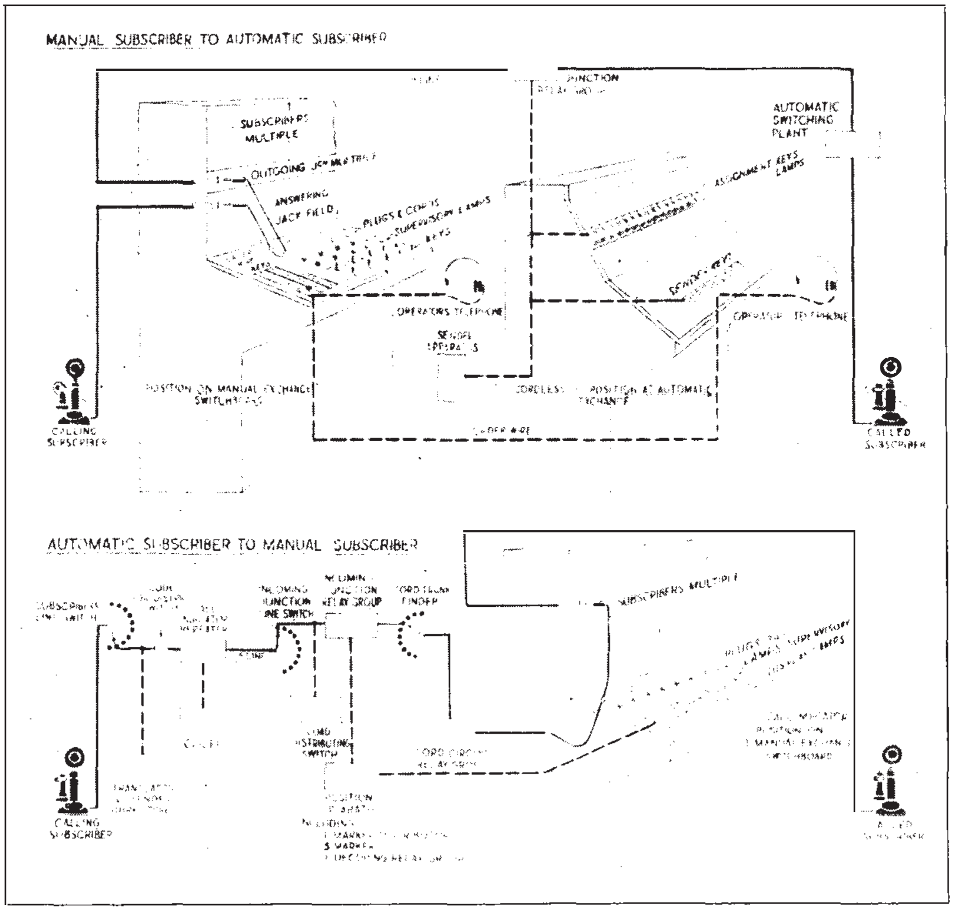
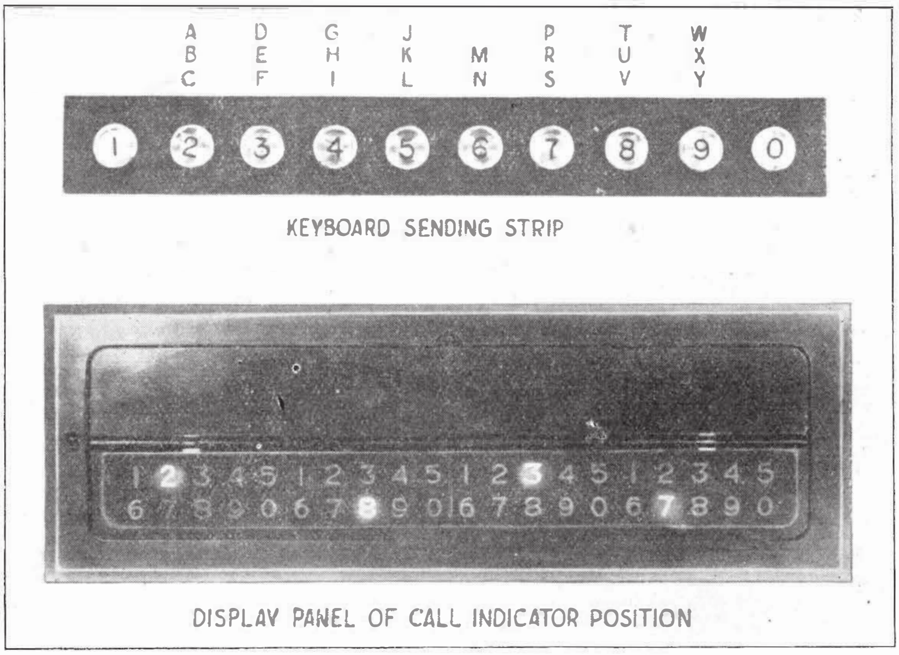


FIG. 8.

" In the converse case for a subscriber connected to an exchange not yet converted to automatic working, two methods are available by which the manual exchange operator may deal with the call if connection with a subscriber on an automatic exchange has been asked for. The first method (see Fig. 8) provides that she shall pass forward the call verbally, by order wire, to an incoming junction operator at a special ' B ' switchboard in the automatic exchange. The latter operator will assign a junction circuit, by pressing an assignment key, and will set up the call by means of a set of plunger keys known as a key sender. The automatic plant does the rest and clears the key sender for further use as soon as the call has been steered through to its destination.

" In the second method the operator who answers the call from the subscriber at the manual exchange is herself provided with sets of key senders, on one of which she can set up the call and so direct it forward through the automatic plant at the distant exchange to the required subscriber's line, without the co-operation of a junction operator. The adoption of one or the other method depends upon the local conditions at the exchanges in the area, but the first method, which avoids the need for special equipment at the answering operators' positions, is generally to be preferred and has been adopted for London. Fig. 9 shows the arrangement of keys on the key senders, and illustrates the manner in which the called number is displayed visually on the call indicator.

" In its operating principles the system of ' call indicator ' working adopted for London is similar to that invented for use in connection with the panel system, but the London system contains several novel features which warrant a further brief reference. It is termed by the Automatic Telephone Manufacturing Co. a ' coder call indicator system ' and its object is to minimize the number of automatic switches necessary to display a call at a manual exchange, and to provide facilities for even traffic distribution of calls from all exchanges among the operators. Its operation is briefly as follows :—



KEYBOARD SENDING STRIP

DISPLAY PANEL OF CALL INDICATOR POSITION

Fig. 9.

" At the originating automatic exchange the director impulses, instead of passing directly to line and to the distant exchange from the outgoing switch, are stored in the relays of an equipment assembly termed a ' coder,' which is at the same time connected to the junction line. At the manual exchange the connection of the coder to the line at the distant end routes the line to a set of incoming ' decoder ' relays by means of a ' marker ' controlled by a ' marker distributor.' Five markers and one marker distributor are provided for each call indicator position. When the junction line had been routed to the de-coder of the call indicator position the coder at the originating end is permitted to discharge. The decimal settings of the coder relays are translated and transmitted over the line as coded impulses of positive, light negative, and heavy negative currents, and stored in the de-coder relays. As soon as the display lamps are freed from the previous call this setting is transferred to a group of numerical relays which cause the called number to be displayed by the lamps in the display panel in the usual way. The arrangements are such that while one call is on display at each position, an indefinite number may be stored on coders at the automatic exchange. Whilst one call is being displayed, five markers per position will be connected to junction lines associated with an equal number of waiting coders, and the traffic will thus be kept in order of priority.

" The discharge of the coders into the de-coding relays occupies 1 second, and transference from the de-coder to the display panel is immediate.

" At the manual exchange, traffic reaches the positions in cyclic disengaged order in quantities that correspond to the operators' abilities, and in queue formation at each position. Positions at which either all receiving relay sets or markers are engaged are treated as busy and passed by the marker distributor. A call displayed on the display panel is not directly associated with any one cord circuit on the position. The plugging-in of any idle cord to the multiple jack of the required number immediately starts a finder switch, which hunts for the calling line, connects the cord to it, and switches out the lamps on the display panel.

" The cords are not normally used for the completion of service calls. Such calls are operated by the depression of a service key which causes a finder switch to hunt for the calling line and connect it to a service operator's position. Busy calls receive the engaged tone by the operation of a key in a similar manner. This reduces the number of cords required, and is a factor of value in some cases where the cord capacity of manual exchange ' B ' positions is restricted.

" Each call indicator position is equipped with 36 cord circuits and it is expected that each operator will handle 450 calls during the busy hour. This is probably a conservative estimate.

" It will be appreciated that before the first equipped automatic exchange can be brought into use the whole of the existing manual exchanges in London must be equipped for call indicator working. It follows, therefore, that during the initial stages of automatic working over 90 per cent. of the automatically originated inter-exchange traffic in London will be handled at call indicator positions. This percentage will gradually decrease as more automatic exchanges are brought into use, and will finally be extinguished. An automatic subscriber, however, apart from any local knowledge which he may possess, will be quite in ignorance as to whether his call is going to another automatic exchange or to a manual exchange. His operations will be alike in both cases—he will dial three code letters and four digits, and in both cases he will receive the same tones, etc., to indicate to him the progress of his call. When complete conversion to automatic working has been effected, the whole of the call indicator equipment will have disappeared, together with all coder equipments at the automatic exchanges themselves.

" It may be urged that this method of tackling the problem is wasteful, inasmuch as call indicator equipments will be progressively thrown out of service during the period of transition. An obvious alternative would be to install automatic equipment at each manual exchange, of a capacity sufficient to deal with the incoming junction traffic and having the subscribers' lines multipled on the final selectors in parallel with the multiple on the manual board. Then when the time arrives to convert the manual exchange to full automatic working the automatic plant already installed could be worked into the full scheme at that or another exchange and little wastage of plant would result. The possibilities of this scheme were fully considered, but serious objections to its adoption revealed themselves. These arose mainly from the lack of adequate building accommodation for the interim automatic plant, from the extensive changes to subscribers' numbers to provide for automatic private branch exchange service which would be immediately necessary, and from the need for expensive additions to the manual exchange power plant in order to permit the use of standard 50-volt automatic switches. Considerable difficulty has, in fact, been experienced in many cases in finding adequate accommodation for the plant required at manual exchanges for the call indicator equipment, although the space required is much less than that needed for the alternative scheme.

" Moreover, the wastage of call indicator apparatus will be minimized by the use in other large areas such as Manchester, Birmingham and Liverpool, of equipment recovered from London exchanges, and probably much of it will remain in service during the greater part of its economic life.

" CORDLESS ' B ' POSITIONS.

" Traffic originated at a manual exchange for an automatic exchange can be handled in two different ways, as already indicated. In the method adopted, each automatic exchange is equipped with special manual ' B ' positions and demands are passed, by order wire, to these positions from the ' A ' operators at the originating manual exchange. The operating procedure at the ' A ' positions is identical with the procedure to manual exchange ' B ' positions. The ' B ' operator at the automatic exchange sets up the call on the automatic switches by means of key sending equipment. As this operator is not required to handle any other class of traffic, key sending equipment is used in preference to dials, since quicker and more efficient operating is obtained thereby.

" The other of these alternative methods would require that all manual exchange ' A ' positions in London should be equipped with dials and dial keys, and, since it would not be possible in many cases to dial from the manual exchange cord circuits directly into the automatic switches, it would be necessary to equip most of the incoming junction lines with ' dialling-in ' repeaters at the automatic exchange. Further, the increased amount of operating per call at the ' A ' positions would so increase the operators' load that a large number of additional ' A ' positions would be required in London to handle the volume of traffic during the busy hour. The cost of adopting this alternative, without serious interruption to service, would be so great, as compared with the cost of the method adopted, that the latter was preferred without hesitation.

" In order to cater for traffic from manual exchanges, each automatic exchange will therefore be equipped at the outset with a suite of cordless ' B ' positions equipped with key senders (see Fig. 8). The key sending equipment consists of a strip of digit keys associated with four sender finders which route the digit keys to a free sender. The registers which are wired to the bank contacts of the sender finder consist of four groups of four relays, one group for each digit. These relays are operated by the digit keys either singly or in combinations of twos or threes to obtain all digits from 1 to 0. The setting of the relays determines the ' marking ' of a contact on the sender switch by means of which impulses are sent out to the exchange numerical switches in a manner very similar to the method used for sending out the numerical impulses from the director.

" The junctions from the manual exchange are brought through the cordless ' B ' position and carried on to a first numerical switch on which they terminate. At the position each junction is associated with a group of relays, and an assignment key and lamp for each junction are fitted as part of the face equipment of the position. The operating procedure is simple and is as follows :—

" The ' A ' operator at the manual exchange passes a demand by order wire to the cordless ' B ' operator. The latter allots a junction and immediately depresses the assignment key of the allotted line. This causes the allotted junction and the operator's digit keys to be connected to a free sender with associated registers. The operator then depresses in proper sequence the four digit keys corresponding to the four figures of the called subscriber's number. These four figures are routed by means of a control switch to the four groups of register relays, which are operated and locked in the proper combination simultaneously with the depression of the digit keys. (After the depression of the last key—the fourth—the set is at once available for another call. The bank contacts of the sender switch are thereby marked and impulses are sent out to the numerical switches. Sending cannot commence, however, until the operator at the manual exchange has taken the allotted junction line. When all sending is finished the sender and registers are disconnected from the junction line and the latter is switched through, *via* the numerical switches, to the called line.

" A supervisory lamp is associated with each junction line at the cordless ' B ' position. After depression of the assignment key on an allotted junction the operator must not proceed with the setting up of the required number on her digit key strip until a signal is received on this lamp to indicate that a free sender has been found. The provision of senders is on such a basis that no delay is likely to occur at this stage. The supervisory lamp will flash until the originating ' A ' operator takes the allotted line, after which it will glow continuously until the ' A ' operator clears at the end of a conversation.

" Should the ' A ' operator connect to a line other than that allotted, the supervisory lamp on that line will flicker rapidly to indicate to the ' B ' operatoı that a wrong connection has been set up.

" Centralisation on Manual Boards.

" When sufficient automatic exchanges in London are in use the cordless ' B ' positions and special ' A ' positions for operator service, etc., instead of being equipped in each automatic exchange, will be centralized, the centres being so chosen, to serve a group of adjacent exchanges, that economical use of line plant is achieved. There will be a number of such manual centres in London when the automatic traffic in the individual areas has reached a certain density. Great advantages in the design and cost of automatic exchange buildings will result from the centralization of manual board traffic, since these buildings will not be required to accommodate the manual switchroom and operators' quarters.

" The Mechanical Tandem Exchange.

" In the London area there are a large number of comparatively small exchanges with small groups of junction lines to and from each of the larger exchanges.

" As a result of the traffic inefficiency of small groups, and of the fact that order-wire working is ruled out, the busy-hour loads carried by these junctions are very low and their operation is uneconomical. Frequent consideration has therefore been given to the introduction of one or more tandem junction exchanges, at which all the junctions to and from each small exchange could be concentrated and thus form a group suitable for order-wire working. Such a scheme could not, however, be shown to possess any economic advantage, on account of the cost of introducing a third operator on each tandem connection. The development of the automatic call indicator scheme increased the possible speed of operating and so favoured the introduction of tandem junction working, and the advantage of introducing automatic tandem switching plant was, naturally, considerably increased by the decision to adopt the automatic system at London local exchanges. The installation of a mechanical tandem exchange has therefore been pressed forward, in advance of the completion of the first local automatic exchanges.

" The mechanical tandem exchange is now being installed in the same building as the Holborn automatic exchange. In it will be concentrated the outgoing and incoming junctions from the smaller exchanges as well as a number of junctions to practically all the other London exchanges.

" At the beginning of its life, and for the period which will elapse before conversion to automatic working in London is completed, the mechanical tandem exchange will be required to route traffic as follows :—

" From manual exchange to manual exchange.
" From manual exchange to automatic exchange.
" From automatic exchange to automatic exchange.
" From automatic exchange to manual exchange.

" The method of handling this traffic is indicated by Fig. 10. Traffic from the ' A ' positions of a manual exchange will be dealt with in a similar manner to the traffic incoming to a cordless ' B ' position at an automatic exchange. The ' A ' operator will ' order wire ' the call to the cordless ' B ' operator at the tandem exchange, who will set up the call to the automatic switches *via* her key sender. In this case, however, since the exchange code must be set up in addition to the subscriber's number, the sender is associated with a translating unit, similar in principle to the director, and with a coder. If the call is for a manual exchange it will be directed to a call indicator position at that exchange, and the numerical portion of the required number—transformed into the correct impulses by the coder at the mechanical tandem exchange—will effect the required display on the lamp panel at the call indicator position. If, however, the call is for an automatic exchange the cross-connections in the translator jumper field will be such as to suppress the operation of the coder, and the numerical digits will go out to the switches at the automatic exchange in the regular manner.

" Traffic originated in an automatic exchange will be carried direct from the levels of the outgoing switches to the first tandem switches at the mechanical tandem exchange. In the case of a call for a manual exchange a coder—interposed between the manual levels on the first tandem switches and the second tandem switches—will come into operation as soon as the second tandem switch has been operated, and the numerical portion of the required number will be stored in the coder and converted, as already described, for display at the call indicator position. A call for another automatic exchange will pass out *via* levels on the first tandem switches which are not equipped with coders, and the call will be routed straight through the switches as determined by the impulses from the director at the originating automatic exchange.

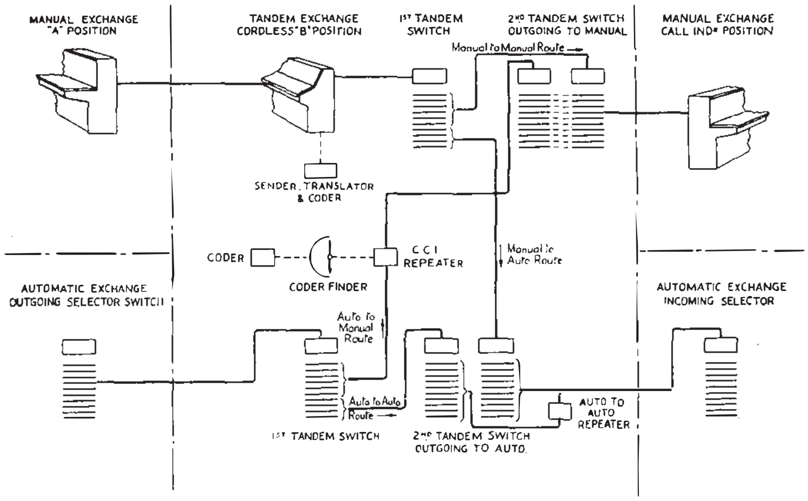

MECHANICAL TANDEM EXCHANGE
ROUTING SCHEME
MANUAL EXCHANGE "A" POSITION
TANDEM EXCHANGE CORDLESS "B" POSITION
1ST TANDEM SWITCH
2ND TANDEM SWITCH OUTGOING TO MANUAL
MANUAL EXCHANGE CALL IND^R POSITION
Manual to Manual Route
SENDER, TRANSLATOR & CODER
CODER
CODER FINDER
C C I REPEATER
Manual to Auto Route
AUTOMATIC EXCHANGE OUTGOING SELECTOR SWITCH
AUTOMATIC EXCHANGE INCOMING SELECTOR
Auto to Manual Route
Auto to Auto Route
1ST TANDEM SWITCH
2ND TANDEM SWITCH OUTGOING TO AUTO.
AUTO TO AUTO REPEATER

FIG. 10.

" As the conversion of London to automatic working proceeds, the traffic incoming to the mechanical tandem exchange from manual exchanges, and the traffic outgoing to call indicator positions, will decrease and will ultimately fall to zero. The whole of the traffic will then be purely automatic, and will be routed direct through the switches, as at other main switching centres in the London system. The cordless ' B ' positions and their equipment will no longer be required for their original purpose, and it will probably be desirable to utilize them for passing traffic from towns in the London toll area into the automatic system. This question will be considered in due course, as the cordless ' B ' positions at the mechanical tandem exchange are freed from local traffic.

" POWER CONSUMPTION.

" At a city exchange of approximately 10,000 lines, and at the mechanical tandem exchange, the operating current at peak load will exceed 2,500 amperes. Two sets of 50-volt storage batteries, each having a capacity of 10,000 ampere-hours, are provided. During busy hours the load on the batteries is eased by running the charging machines in parallel with them.

" VARIOUS CLASSES OF SERVICES PROVIDED.

" The subscribers connected to an automatic exchange will be divided into two groups: (*a*) those to whom trunk calls are permitted and (*b*) those to whom trunk calls are barred. The distinction is of course of the subscribers' own seeking, but it is necessary that the department should guard itself against improper use of the trunk lines by those subscribers who are not entitled to this service. A subscriber who requires a trunk connection will dial TRU if on a director exchange. (The letter ' O ' is used for this purpose at non-director exchanges in the provinces.) In the group where trunk calls are permitted the call will be routed to a record operator, but in the group where such calls are barred the call, if made, will be routed to a special operator and dealt with accordingly.

" Subject to this restriction the following classes of service will be provided:—

Subscriber to subscriber—direct.
Subscriber to subscriber—over junction circuits.
Subscriber to subscriber—over trunk lines (' revertive ' calls).
Subscriber to subscriber—over toll lines (' no delay ' calls).

Coin-box stations and call offices to and from all other subscribers in the system direct, or over junction, trunk, or toll lines.
Private branch exchange traffic with night traffic on selected lines in each group of exchange lines.
Inquiry, information, and directory services.
Dictating messages for onward transmission as telegrams, express letters, or letters.
Receiving telegrams in lieu of delivery by messenger.
Calling for the services of express messengers.

" TONE SIGNALS.

" A system of tone signals designed to give a calling subscriber knowledge of the progress of his call has been standardized for use in both London and the provinces. Before commencing to operate his calling dial the subscriber should listen for a ' dial signal tone,' which indicates that a free selector in the first rank—or, in London, an ' A ' digit switch—is available to receive the dialled impulses. Dialling must not commence until this tone—which is continuous at a frequency of 33 per second—has been received.

" If the called subscriber's line is engaged, or if, at any stage of the call, all outlets from a selector switch level are busy, a ' busy tone ' will be sent out. This tone has a frequency of 400 per second and is applied for ' off and on ' periods of 0.75 sec. The tone is associated with a flashing signal on the supervisory lamp of an operator's cord circuit in the case of a call from a manual exchange subscriber.

" When dialling is completed the subscriber will immediately receive ' ringing tone ' to indicate that the required subscriber is beng rung, or ' busy tone ' to indicate that he is already engaged. The ringing tone is provided by means of a leak from the ringing circuit through a condenser of small capacity on which current pulses at a frequency of 133 per second are superposed. This tone is applied to the line with the same interruptions as the ringing current itself, *i.e.*, a double beat of 1 second with a 2-seconds' interval. The double beat consists of two rings of 0.4 second duration separated by an interval of 0.2 second.

" In areas where the director is not used a further tone known as the ' number unobtainable tone ' is employed to indicate to the subscriber that he has dialled a ceased or unallotted number. In London this tone will be used to indicate to a subscriber that he has incompletely dialled the required number. Calls for ceased or unallotted numbers will be routed to an operator.

" PRIVATE BRANCH EXCHANGE LINES.

" Most private branch exchanges have more than one line to the exchange and it is of course necessary to arrange that, if a call be received when the particular line representing the exchange number of the private branch exchange (PBX) is engaged, the calling subscriber shall not receive the ' busy ' signal unless all the lines to the PBX have been searched and also found to be engaged.

" It is therefore necessary to arrange that the group of lines to a PBX shall be connected to consecutive positions on the bank multiple of the final switches and to provide all switches on which such groups of lines terminate with means for continuing their rotary motion as a hunting operation throughout the group—after the impulses of the units train have carried their brushes to the first line of the group—until an idle line is found, or the whole group has been searched without success.

" Switches provided with this facility are known as ' rotary final switches ' or ' rotary connectors.' In the case of PBX groups of two or three lines no special difficulty arises, apart from the fact that all the lines must appear on one level of the switch and that a few spare positions for future growth must also be left upon that level. This tends to a certain amount of plant wastage, and also generally involves changing the exchange numbers of a proportion of the subscribers in order to get them properly grouped on the levels of the switches when a transfer to the automatic system is made.

" When, however, the present or probable future requirements of a PBX exceed 10 lines, and therefore exceed the accommodation of a normal switch level, it is necessary to take special steps to ensure the availability of all the lines when a switch is hunting to complete a call for the PBX number. Line-hunting over groups up to 20 in number can be provided by utilizing rotary final switches having 10 double levels of 20 contacts. Each such level absorbs only 10 line numbers in the subscribers' multiple series, the remaining 10 having auxiliary numbers. This scheme is therefore economical from an exchange plant standpoint, as the line capacity of the exchange is not reduced by the existence of lines 11 to 20 in the group, or by the retention of some of these auxiliary positions as spare for the future requirements of the PBX in question.

" The private branch exchanges serving some of the large London stores have 150 exchange lines or more, but it is generally possible to divide the lines so that a group not exceeding 100 is available for outgoing traffic at the public exchange. In such cases additional switches of the pre-selector type are connected to the normal outlets of special third numerical selectors which act as final switches. The 10 outlets of the level appropriated to the PBX in question on each switch are multipled on a graded basis to ' homing ' pre-selectors having access to all the PBX lines in a common group of approximately 50 or 100, according to requirements. Each pre-selector is associated with a set of repeater equipment which provides facilities for battery feed, busy test, ringing and registration.

" In this way all the requirements of very large private branch exchanges can be met in a perfectly satisfactory way, although with a certain sacrifice of uniformity as compared with systems deliberately designed for searching over large groups of lines."

Details were given of the new Post Office standard automatic dial which has been designed to provide the following facilities :—

(1) Immunity from the bell tinkling without the necessity for biassing the bell.

(2) The suppression of the inductive voltage kick during dialling.
(3) The use of a three conductor cord on table sets.
(4) Minimum impulse distortion.

The dial is illustrated in Fig. **11** and the telephone circuit in Fig. **12**. The abolition of the need for fitting bells with special biassing devices and the adoption of a circuit utilising the existing C.B. wiring at subscribers' premises in London is estimated to effect a saving of approximately £100,000 in London alone.

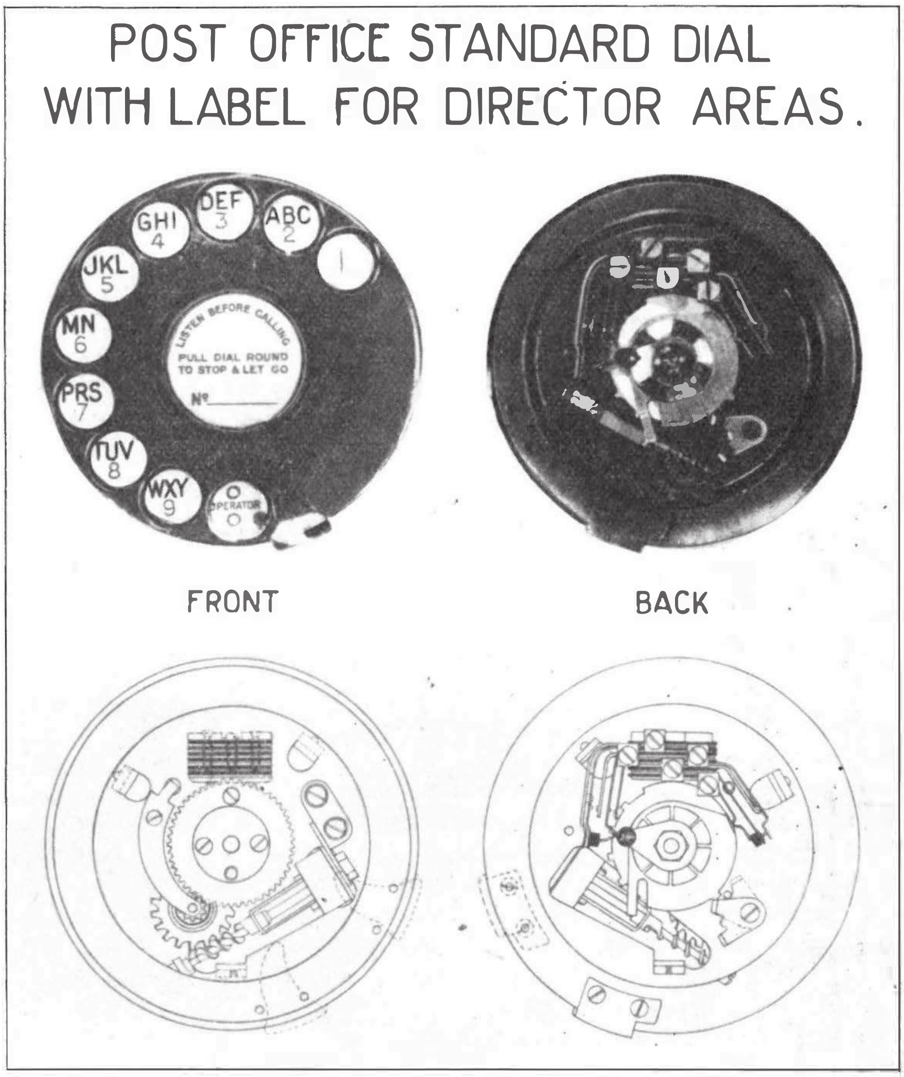

POST OFFICE STANDARD DIAL
WITH LABEL FOR DIRECTOR AREAS.
ABC 2
DEF 3
GHI 4
JKL 5
MN 6
PRS 7
TUV 8
WXY 9
OPERATOR 0
LISTEN BEFORE CALLING
PULL DIAL ROUND TO STOP & LET GO
No
FRONT
BACK

FIG. **11**.

The discussion on the paper was very interesting and referred mainly to the importance of the introduction of the new telephone circuit, the adoption of grading and the standardising of loop dialling and the principle of translation.

The Author's replies in connection with these subjects are indicated in the following extracts from the official report of the discussion :—

" Colonel T. F. PURVES (*in reply*) : I recognize that my paper contains a good deal of technically contentious matter, regarding which it is out of the question to expect universal agreement, and I appreciate the generally helpful and constructive character of the comments made upon it by so many speakers and contributors.

" I agree with Mr. Laidlaw and Mr. Hollings that a considerable proportion of subscribers will probably not listen for the ' dialling tone ' before making a call, at least in cases where the tone is a subsequent addition to an automatic system with the operating of which they have already become familiar. But when the tone has been a feature of the system from their first acquaintance with it—and this will apply to the great bulk of British subscribers—I think it will be used much more systematically, even if in more than 95 per cent. of the cases no trouble will arise from ignoring it. If a call has, for any reason, been ineffective, and the familiar ringing signal is not heard, subscribers will generally learn to listen for the dialling tone before making a second attempt. The tone is also very useful if it is desired to originate a call immediately after completing an incoming call from a private branch exchange, or from a manual or trunk exchange, as its presence is an indication that the connection has been cleared by the operator and that the line is again available. I may remark that the dialling tone is produced by the simple interruption of a battery circuit by an additional running commutator on the general tone-producing machine. There are no difficulties, and little expense, involved in its provision. Mr. Hall suggests that the tone should only be audible where a primary outlet to connecting plant is not available, but under these conditions its presence would be such a rarity that its meaning would probably be forgotten altogether or be confused with that of the ' busy ' signal. I think it is preferable to utilize the tone as a positive indication that the line switch has found an outlet and that calling conditions are normal. The fear that a subscriber whose line is faulty may assume that the absence of the tone indicates non-availability of outlets, and may therefore refrain from reporting the fault, has not much foundation ; subscribers speedily become familiar with the many audible indications that a line is ' alive,' as compared with the ' dead ' condition of a faulty line.

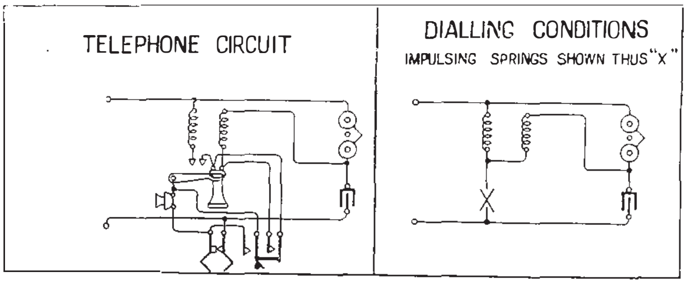


FIG. 12.

" Mr. Nash makes a kindly and generous reference to the amount of work and responsibility which has to be shouldered by the Post Office engineering staff in connection with such questions as the equipment of the London telephone system with automatic plant, and I greatly appreciate his expression of confidence in the success of the system which has been adopted. At the time when I had to take my courage in both hands and decide to turn away from the practice of the great American Bell telephone organization, for whose example we have so high a regard, I should have been very gratified indeed to know that, even before our first exchange had been installed, one of the leading engineers of the Western Electric Co. would so express himself. Mr. Nash presents an interesting table in which the number of secondary selecting switches, which would provide full trunking availability, is compared with the additional trunks required to furnish the same standard of service by means of 10-contact switch levels on a direct, graded, basis. I agree that a perfectly satisfactory circuit for secondary pre-selecting switches has not yet been forthcoming, although some telephone administrations appear to be prepared to adopt secondary switches to a considerable extent. Their use, of course, introduces additional switching points which undoubtedly complicate the tracing of calls and, to that extent, hamper the work of the maintenance staff. It is not easy to visualize the service-degrading factor introduced by outgoing secondaries, but it is obvious that without such devices the system is cleaner and easier to maintain. It is felt that the present system introduces quite enough complication and innovation for the maintenance staff to assimilate at the outset, but the Post Office has by no means ' burned its boats ' in this matter. The economies due to the utilization of large groups of selectable junction circuits, and the possibilities presented by the use of secondary switches as a means to that end, are fully appreciated. In the first automatic exchange installed in London, provision is being made for associating outgoing secondary switches with junctions to selected exchanges, so as to obtain actual working experience in the handling of junction groups up to a maximum of 100 lines. If satisfactory service is afforded by this method, there will be no hesitation to adopt it in cases where the overall annual charges will be sufficiently reduced by so doing, which are, of course, likely to be those cases in which the junction circuits are long and of heavy gauge.

" Mr. Morley Ward inquires as to the reason for the adoption of the plan of sending dial impulses around the loop of a junction circuit, instead of over one conductor of the line or over both conductors in parallel. Mr. Christian also refers to the same point. This matter was given very close study, as it was fully realized that the adoption of loop-impulsing would mean a considerable reduction in the permissible maximum resistance of junction circuits, and that, with the impulse-receiving relays at present available, it would in some cases involve the use of heavier-gauge junction circuits than would have been necessary from the standpoint of speech-transmission efficiency. The main consideration in favour of loop-impulsing is, of course, that it provides security against the inductive interference of power and lighting circuits with the telephone signalling impulses. Tests were made from the Central exchange, to various points in London, by means of recording apparatus connected in earthed circuits. The records showed a certain amount of inductive interference, although surges of sufficient magnitude to affect dial signalling were so rare that it seemed improbable that they would in general affect the number of call failures to any recognizable degree. It was felt, however, that abnormal conditions due to faulty power circuits might sometimes cause more or less acute local trouble, and also that the general development of electrical supply systems, and of railway electrification in London and throughout the country during the next decade, might, in spite of the statutory safeguards of the Post Office against prejudicial interference with its communication services, have the effect of progressively worsening the conditions. It was therefore thought desirable to standardize, from the commencement, a system which would enable the department to demonstrate, in any case of trouble, that its own plant was so constructed as to secure the greatest possible immunity from outside electrical interference.

" I am glad that Mr. Morley Ward mentioned the early pioneer work of Mr. William Aitken in connection with the invention of multi-choice grading : this might well have been referred to in the secton of the paper dealing with that subject.

" Mr. Carter and Mr. Harrison both refer to the ingenious pre-director development known as the ' universal switcher.' This system was the subject of interested attention by the Post Office, but we did not at any time feel inclined to adopt it. In addition to the wasteful use of junction plant, which both speakers mention, it required a completely predetermined numbering scheme, and therefore did not obviate some of the main difficulties involved in the introduction of an automatic scheme in large multi-office areas.

" Mr. Deakin has given much information that is both interesting and valuable to a student of the subjects he refers to. I am not quite sure that, in his references to the method of grading illustrated in Fig. 12, he is not overlooking the fact that the advantage of grading from 24-point pre-selectors is not merely the 15 per cent. increase obtained in the traffic-carrying capacity of the first code selectors. By suitable selection of subscribers' lines for connection in each group of 75, and by grading as indicated, the large block of traffic originated by 1,200 subscribers is turned over with approximate uniformity to the outgoing multipled circuits of the selector groups. It is thus presented to the succeeding graded ranks of switches in more manageable form, and the effect of this is to improve the carrying capacity of these subsequent switches, as well as that of the first code selectors. Special traffic curves making allowance for this fact are used in designing the layout of automatic exchanges. The maximum increase in traffic-carrying capacity that can be claimed for ordinary grading from 10-point selector banks throughout the switching system is about 30 per cent. It should be noted also that a graded system using 20-point selector banks has still to be studied, and that this may modify the economic comparison with outgoing secondary switches. A factor to be borne in mind is that the largest groups of junctions are required between large exchanges and that such exchanges, in London, are fairly close together. The circuits in these large groups of junctions thus tend to be both short and of light gauge, and their cost is correspondingly low. As regards tandem working, it should be remembered that the mechanical tandem exchange is being introduced to supersede the direct trunking of small groups of three or four lines. The change from these very inefficient groups to groups connected on a graded basis to 10-point contact banks represents a very material advance.

" As regards the system of service to be adopted for communication between manual and automatic exchanges, it must be recognized that a system which may be specially adapted at the outset to requirements may be unsuitable at later stages. There is no question that the most convenient method of equipping the first group of automatic exchanges in London is the provision of ' Cordless B ' positions, but a time will no doubt come when it will be economical to install sending equipment at the 'A ' operators' positions in the remaining manual exchanges. A study of the comparative economics of dials and key-senders for this purpose has been scheduled for attention in due course. It may well be that considerations of space available in the different manual exchanges will dictate treatment of each on its individual merits. A powerful factor in favour of key-senders will always be the fact that the introduction of these high-efficiency devices reacts favourably on the load which can be carried by ' A ' operators, and has the effect of increasing the traffic-carrying capacity of manual exchanges and avoiding the extension of obsolescent plant.

" I am rather surprised by the emphasis with which Mr. Deakin depreciates order-wire working in general, in spite of the fact that I have always had a decidedly soft side for the alternative of a properly developed direct trunking system. I can assure him that, although his remarks may be justified from the experience and practice of some administrations, they do not apply in this country, where the order-wire system has always proved reasonably satisfactory. The system has to be kept clean ; split order wires and tandem order wires are things to be avoided, and perhaps these points have been ignored by those administrations in whose service he reports that the system has been ' a dismal failure.'

" Mr. Grinsted has brought into prominence the very large number of separate switch movements, and circuit openings and closures, involved in the setting up of a connection in the automatic system. It would, indeed, be a hopeless mental task, even for the most expert automatic engineer, to visualize all that is taking place during the few seconds he is engaged in turning in a call on his telephone dial in a ' director ' area. The figures Mr. Grinsted produces show in a striking way the extreme need for the most efficient maintenance of exchange plant.

" His suggestion that congestion at the switches might be minimized by some method of instantaneously throwing back, to the incoming line switch, false calls caused by permanent loops due to line faults, as well as ' busy ' calls blocked at any point by traffic congestion, is legitimate and the subject is well worthy of attention. It has, indeed, already been considered very carefully, but no way of effecting the desired result has yet been found without involving an additional circuit complication which has to be repeated so frequently throughout the exchange that it is not considered desirable to introduce it at present. The aggregate switch occupation caused by ' busy ' calls will probably not be great, as the subscriber will in most cases release the switches at once by restoring his receiver to the switch hook. False calls due to faulty lines can, with a proper system of alarms and guide lamps, speedily be traced back to the main distribution frame and there plugged out. The London exchanges are therefore being arranged to deal with abnormal loads of this kind by the ordinary supervisory methods of maintenance hitherto employed at all automatic exchanges.

" Mr. Hollings has touched upon one of the disappointing features of automatic telephony, namely, its failure to provide economically for rural telephone service. Mr. Baldwin also referred to the same point. This subject is not altogether within the scope of the paper, but I may say that continuous attention is being paid by the Post Office engineering department to the special problems of rural automatic exchanges. Even at the smallest automatic exchange it is necessary to have a few costly fundamental items for the use of all the subscribers in common, and when the number of lines is small the cost per line of these general items is very high, especially if an electrical power supply is not available. It is then necessary to install an engine and secondary-cell-charging machine, with comparatively high capital and maintenance costs. These restrictions represent part of the price which this country has to pay for its low general development of the use of electrical energy. The extension of rural automatic exchanges will probably follow rapidly on the extended distribution of electrical power in rural communities.

" I have already referred to Mr. Hollings's remarks on the subject of the dialling tone.

" Mr. Hurford has taken rather too literally my round figures of the increase in trunk-hunting capacity secured by the use of secondary switches; I quite agree that 100 per cent. efficiency could not be obtained in practice. Actually the efficiency of, say, a 10-point primary pre-selector, working into a 10-point secondary pre-selector, may be taken as approximately 85 per cent.

" I am sorry if Section (5) of the paper is calculated to give the impression that designers of large-capacity switches are thought to have been working along the wrong lines. This inference was certainly not intended to be drawn in any general sense. Indeed, in Section (9) I say that the facility for direct selection in large groups is a feature of great utility which was reluctantly given up on account of its essential incompatability with the system which had been adopted for standardization in this country on broad considerations of preponderating advantage. My statement of the capacity of panel automatic exchanges in the service of the American Telephone and Telegraph Co. was based on a summary of the position, prepared in America, which I receive every six months. The latest summary referred to the beginning of this year and included 53 exchanges, with total equipment for 273,167 lines.

" Mr. Hurford states that his much larger figures (58 exchanges with capacity for more than 400,000 lines) include extensions to the original equipment. It therefore seems probable that the summaries in my possession represent the line capacity of each exchange as it stood at the date of the ' cut-over.'

" I quite agree that the amount of call indicator equipment in London will go on increasing for several years before it passes the maximum and begins to become surplus. Mr. Pook also makes a reference to this point. The amount of such equipment used in any particular manual exchange will, of course, steadily increase until the exchange is converted to automatic working, and therefore the last exchange to be converted will have the whole of its ' B ' positions equipped with call indicators. There is no intention that the initiation or the progress of the conversion of provincial city areas to the automatic system should be in any way dependent upon the rate of recovery of surplus call indicator apparatus in London."

The press reports of this paper were numerous and it has been reprinted in *ex tenso,* in American and other journals. The following, which appeared as a leading article in the *Electrical Review* for March 20th, will perhaps be of interest to our readers as bearing on British Post Office policy during recent years:—

" THE POST OFFICE AND AUTOMATIC TELEPHONES.

" The masterly paper that Col. T. F. Purves, Engineer-in-Chief to the Post Office, read before the Institution of Electrical Engineers on the 5th instant (an abstract of which is concluded in this issue) has a wider circle of interest than even the very large audience that attended. The present position and policy of the Post Office with regard to automatic telephony emphasise the important work that it has performed in building up a national industry, for the British telephone manufacturing industry is a direct outcome of Post Office policy, and the annual value of telephone manufactures produced in this country now runs into the tens of millions sterling. It will be agreed that the Post Office has performed a great national service in this respect.

" Although for various reasons the present telephone development of this country is below what should, and could, be achieved, the progress that is being made is gratifying. In October, 1922, the number of subscribers' telephone stations in Great Britain reached one million, and new stations were being added to the system at the rate of about 5,000 per month. The number has now increased to 1¼ million stations, and new subscribers are being connected at a rate representing a net increase of about 10,000 stations per month. In other words, the system has increased by 25 per cent. in 2½ years, and the rate of increase has, itself, doubled in that period. There is no sign of a diminution in the rate of growth, and the recent formation of the Telephone Development Association to undertake publicity will tend, of course, to hasten it.

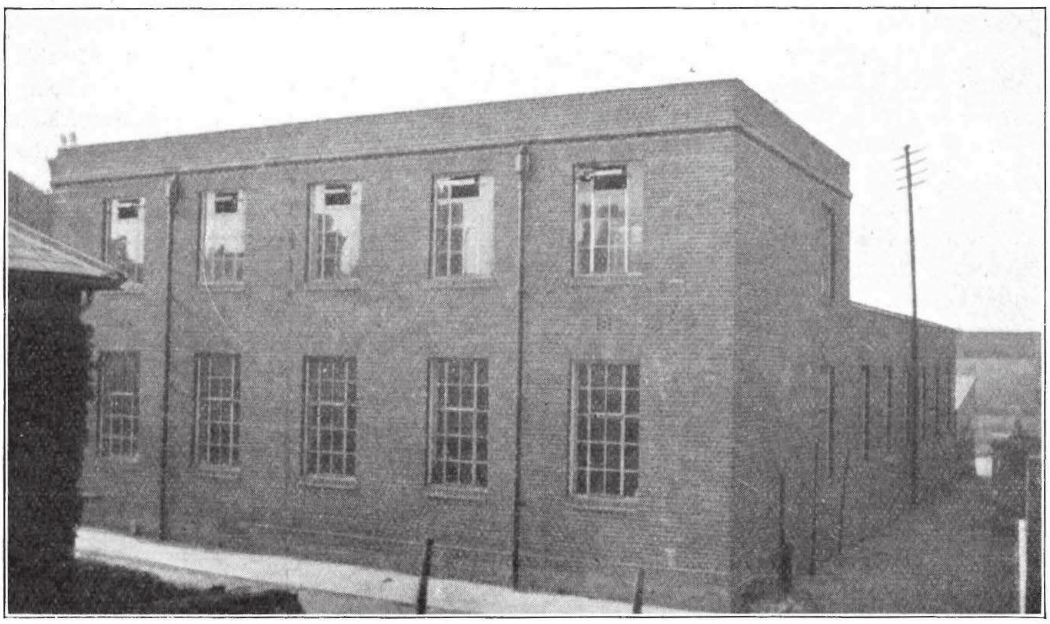
" Mr. G. H. Nash, in the discussion on Col. Purves's paper, drew attention to the fact that there was no mention therein of the large amount of research and the numerous ' studies ' that had been necessary on the part of the Post Office staff before a standard could be adopted. In view of the very extensive organisations in the United States that have been in existence for some years for the purpose of dealing with this kind of work, it is only just that the work performed by the Post Office in this country should be recognised. The Post Office, in dealing with the position here, has in some respects a more difficult task than have the American telephone companies in that the Post Office policy has been to encourage a number of *different* manufacturers with a view to securing competitive contracts, whilst in the Bell system one firm manufactures the bulk of the plant. That being so, it is necessary for Post Office engineers very definitely to specify the requirements that have to be met, and to do so in a way that will not hamper particular manufacturers. It follows that the Post Office staff must act as arbitrators in selecting schemes put forward by the different manufacturers, and to do so it has been necessary to build up a body of experts able to express authoritative views and to secure manufacturing co-ordination. This has had a general beneficial effect in that the Colonies and other telephone administrations repeatedly order telephone equipment in Great Britain to Post Office specifications, being satisfied with a product that has the approval of the British Post Office. A measure of standardisation has been achieved that is somewhat surprising, but Col. Purves was careful to point out that the standardisation already accomplished had nothing to do with any ideas of finality or fixation of practice; improvements emanating from any source in future would be introduced if the public service would benefit thereby.

"An important point in connection with the introduction of automatic equipment is the necessity for maintaining a highly-skilled staff for the operation of the plant; without this skill the policy will fail. To meet this need, it has been found necessary to set up a very completely-equipped training school in London which is intended to cover, not merely the theory, but also the practical side of automatic telephony."

THE ALDEBURGH TELEPHONE REPEATER STATION.

R. J. Nunn, A.M.I.E.E.

This Repeater Station, the building to accommodate which was erected in 1924, was brought into use early in 1925. The station is situated at the southern end of the small seaside town of Aldeburgh, on the east coast of Suffolk. It was provided for repeating the Anglo-Dutch circuits for continental telephone traffic at the junction of the submarine and land cables.



Aldeburgh Telephone Repeater Station.

The building consists of a basement for Central Heating Boiler, Cable Chamber, etc.; a ground floor which accommodates the Power Plant and Batteries; a first floor on which are the Repeater Rooms, Staff accommodation, etc.

The site is within 50 yards of the sea; the submarine cables are brought in direct and led into the building through an underground chamber opening out from the basement and thence up to the Repeater Room.

The Power Plant and Batteries were erected by the General Electric Co., and the Repeater Plant by the Western Electric Co. The leading-in, main cable work and balances were installed by the Department's own staff.

A brief general description of the plant installed is as follows :—

POWER PLANT.

The power for all purposes of the station is supplied by its own plant; the main source of supply being two "Ruston Horizontal, Single Cylinder, Airless Atomiser, Cold Starting, Crude Oil Engines" of 31 normal B.H.P. These engines are started up by means of compressed air. Their flywheels are 7 ft. diameter, 10 inch face, weigh 2½ tons, and run normally at a speed of 265 R.P.M. The engine bed foundations are specially constructed with sand pockets around them to reduce vibration to a minimum.

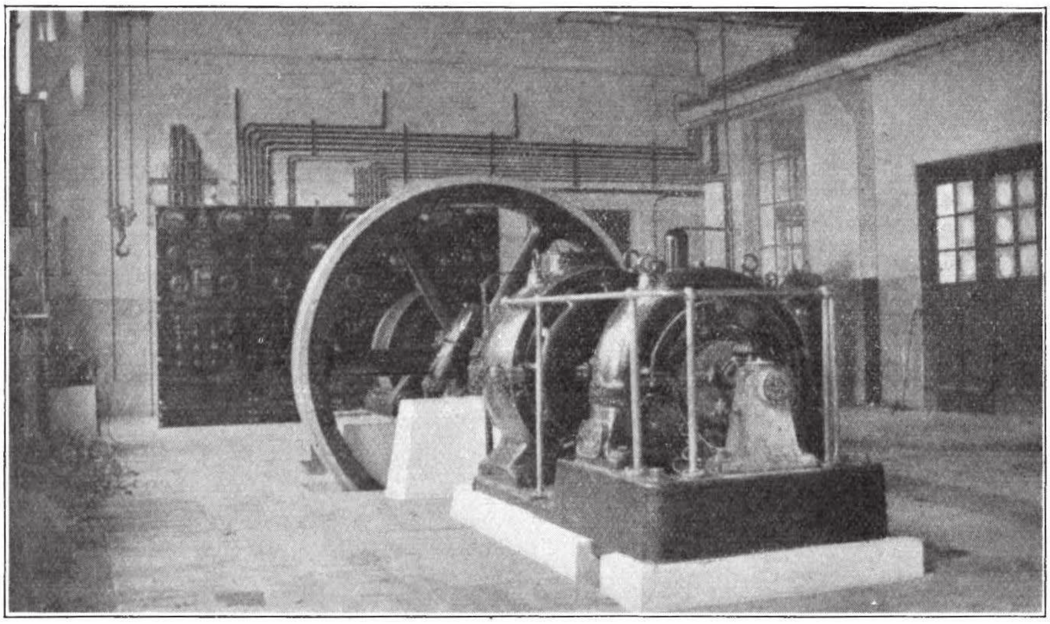


FIG. 1.—ONE SET ENGINE AND DYNAMOS.

Each engine is direct coupled to two dynamos, one of which gives a voltage of 24 to 32 at 150 amps., the other 150 to 220 volts at 50 amps.; the two dynamos are on one bed. Fig. 1 shows one of the engines with relative dynamos and the power board in the background.

The crude oil fuel is stored in two 1,300 gallon tanks in a chamber below the yard adjacent to the power room. This oil is pumped to two intermediate tanks in the power room, holding 100 gallons each; thence it is fed by gravity to two service fuel tanks of 15 gallons each, one serving each engine.

Associated with the engine water cooling arrangements are Monitor Valves, which automatically cause an audible and visible alarm to be given in case of failure in the water circulation whilst the engines are running.

In addition to the main engines and dynamos the following auxiliary machines are provided in the power room:—

Two Rotary Fuel Pumps to raise the fuel oil from the storage tanks.

Two Air Compressors for engine starting purposes.

Two Heenan Coolers for engine water cooling.

Each of these is driven by a separate electric motor.

Two Ringing Dynamotors for supplying ringing currents to the Repeater units.

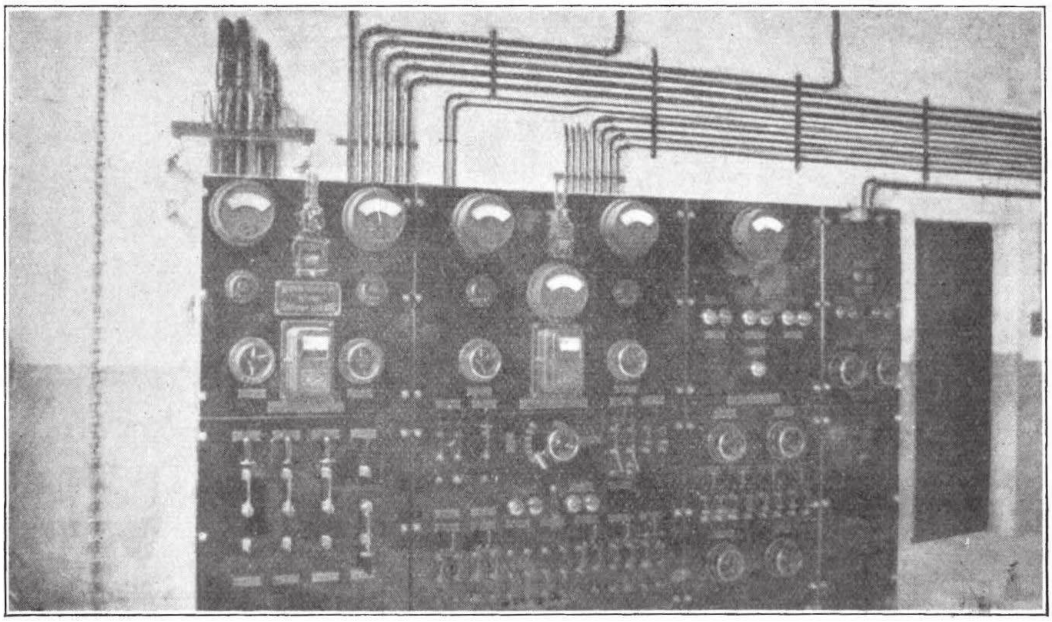


Fig. 2.—Power Board.

All the power plant is thus duplicated and all pipework is interconnected to reduce the risk of failure to a minimum.

A Travelling Crane, by Morris, with a carrying and lifting capacity of 1¼ tons runs the whole length and width of the power room.

The Power Panel, which is shown in Fig. 2, is fitted with Voltmeters, Ammeters and Wattmeters for the main circuits, and full control switches for each battery, generator, and motor.

BATTERY ROOM.

The Batteries supplied are the D.P. Company's make and are as follows :—

Two A Batteries, 12 cells each of 400 A.H. capacity, with space for enlarging to 800 A.H. These batteries are used for the filaments of the valves, also for the relays and the alarm circuits.

Three B Batteries, each of 75 cells and 200 A.H. capacity, supply the anode voltages, electric lighting of the building and the power for the auxiliary motors.

Two C Batteries, each of 5 cells and 30 A.H. capacity, supply the grid voltages.

Two D Batteries, each of 10 cells for counter E.M.F., are used in opposition to the B voltages in the plate circuits.

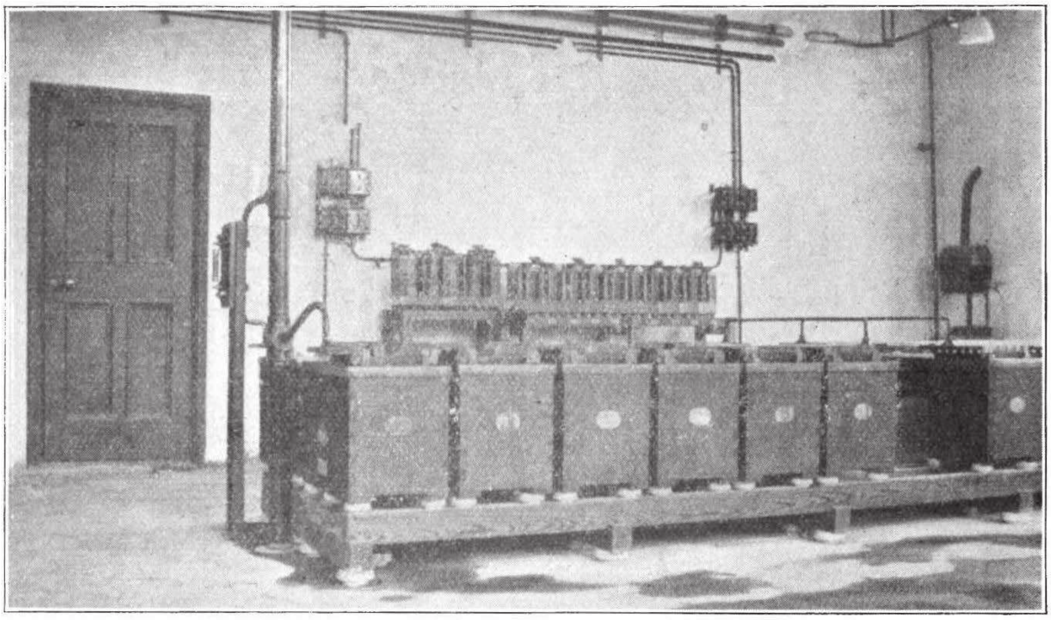


FIG. 3.—ONE SET OF A. BATTERIES.

There are 70 lighting points in the building supplied with current from the B Batteries. Fig. **3** shows one A Battery and part of the D Batteries. Fig. **4** shows two of the three B Batteries.

REPEATER ROOM.

One Repeater Rack with 8 bays is installed, on which are fitted 16 Western Electric No. 22 type, through line, two-wire Repeaters with filters on up and down sides. At the time of writing there are 9 of these in use.

The necessary auxiliary testing apparatus is fitted on this rack, which includes a Gain measuring set with Oscillator and Amplifier, monitorial speaking arrangements, meters and control panels.

Audible and visible alarms are associated with repeater battery circuits, which actuate if the voltages or currents fall below or rise above certain limits. A no-ringing alarm is also provided.

There is space on the repeater rack to fit a further 16 units. Figs. **5** and **6** give front and back views of it, with covers removed from 5 of the units.

The Balances, Transformers and Line Test Tablets are fitted on a separate rack in the same room. This room is capable of taking a second repeater rack without structural alterations and arrangements are already in hand for installing one of 9 bays to be fitted with 13 four-wire Repeaters and terminating sets, together with fuse and resistance panels, etc. Full Repeater and Cable Test Desks will also be installed in the near future.

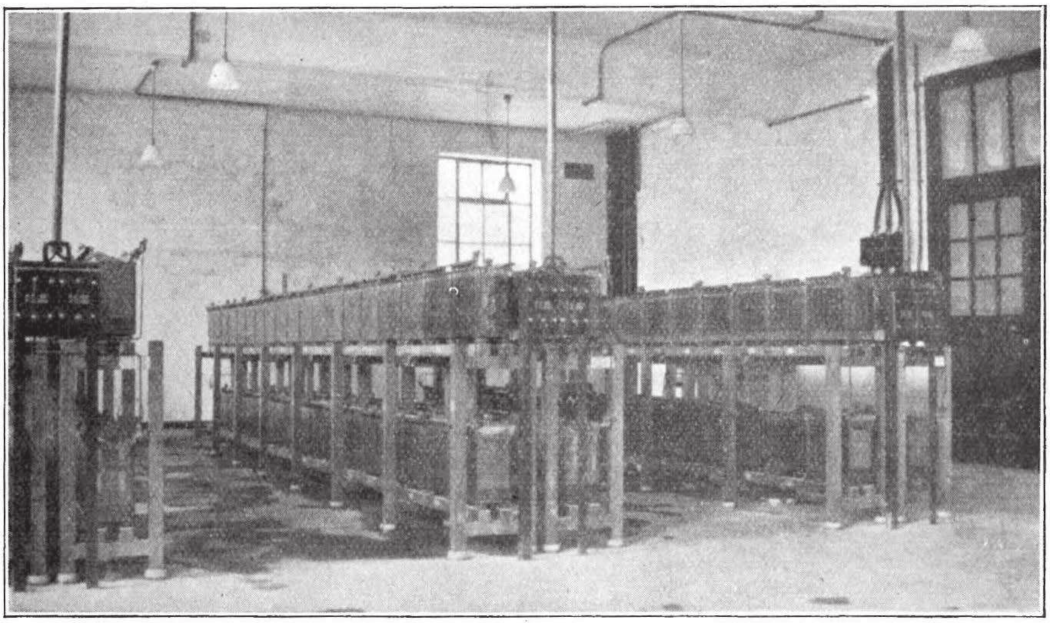


FIG. **4**.—TWO SETS B. BATTERIES.

A separate room has been provided for Telegraph Repeaters should they be required.

LINES.

On the land side the lines led into the building at present are 2 pairs of open 600 lb. copper wires and a 14 pair underground cable, 150 lb. conductors, coil-loaded. A further 38-pair cable, 20 lb. conductors, 28 pairs of which will be coil-loaded, will be completed early in 1926. Messrs. Johnson & Phillips have been the contractors in supplying and laying both cables.

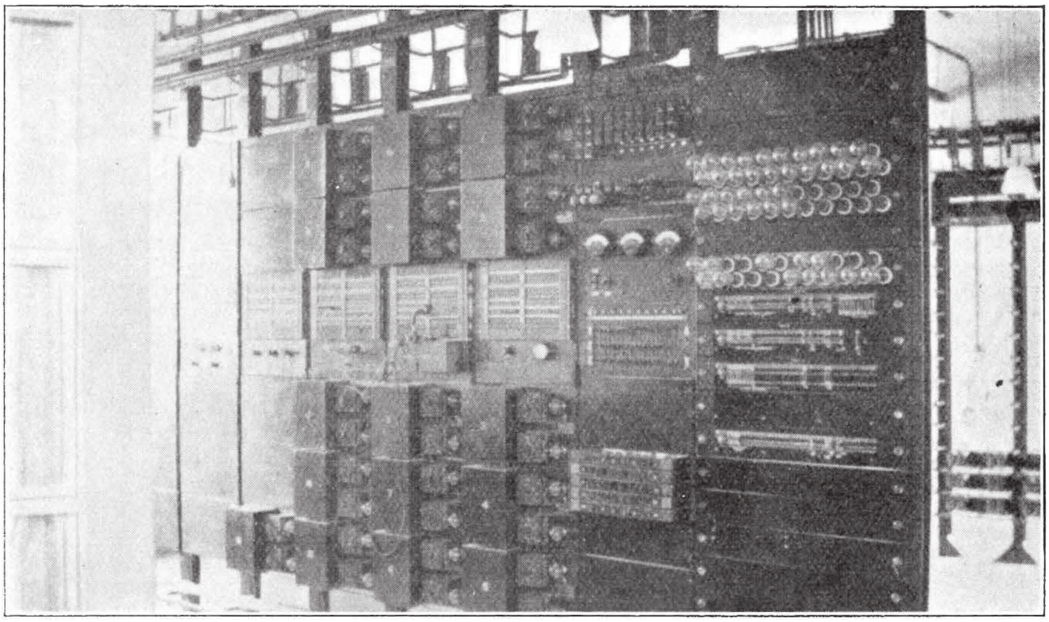


FIG. 5.—REPEATER RACK, FRONT.

On the submarine side there are two cables, one a 4-core G.P. 160 lb. (per naut. mile) conductor, coil-loaded; the other a 16-core A.S.P.C. 165 lbs. (per naut. mile) conductor, continuously loaded, double lead sheathed. These cables land at Domburg in Holland and are approximately 82 naut. miles in length. (An article on the 4-core cable appeared in the *P.O.E.E. Journal* for January, 1924).

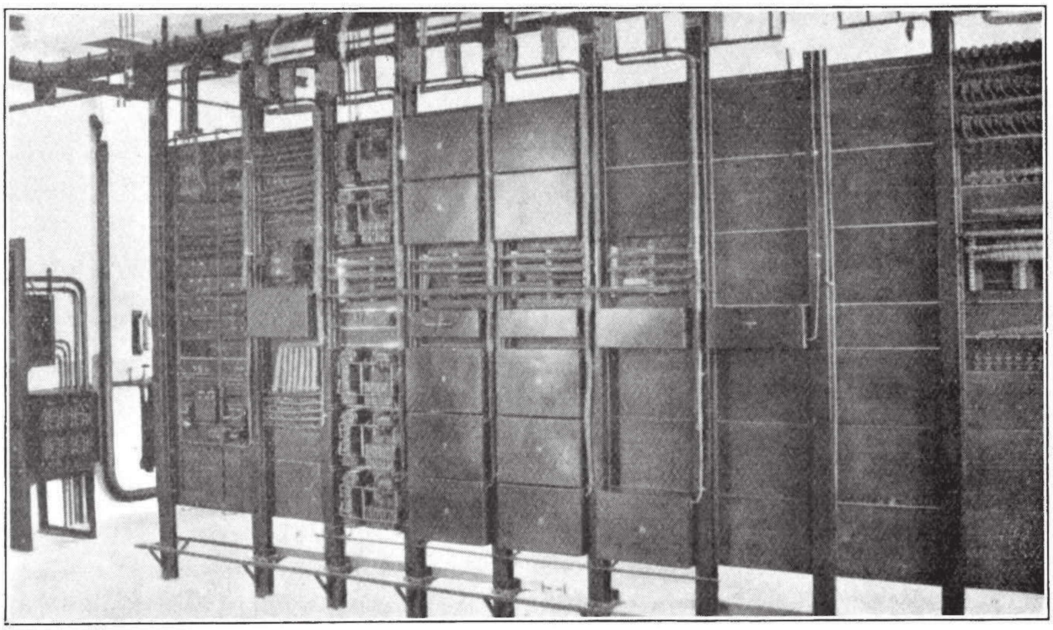


FIG. 6.—REPEATER RACK, BACK.

The following circuits are at present in use:—

6 London to Amsterdam.
4 London to Rotterdam.
1 London to The Hague.

Two of the circuits are worked phantom on the Submarine side and one on the Land side. Two circuits are not repeated at Aldeburgh.

The photos for this article were taken by Mr. W. E. Everson, a member of the Station Staff.

POST OFFICE SERVICES: PROVISION OF INCREASED PUBLIC FACILITIES BY MEANS OF KIOSKS.

F. McClarence, A.M.I.E.E.

Except in the case of large and important Post Offices public business is generally not transacted during the late evening or the greater part of Sunday, and the majority of sub-offices are closed also for an hour daily at midday and for one afternoon each week: during these periods the telephone service is usually in operation and, of course, letters may be posted, but the telephone call office at the P.O. is not available nor can postage stamps be purchased.

It is not surprising, therefore, that demands have arisen for facilities for making telephone calls and obtaining stamps, and that in consequence two interesting extensions of the public service have now been definitely instituted, namely, the provision, in easily accessible positions, of street kiosks for use as telephone call offices and of stamp-vending machines. Incidentally, these facilities not only meet the original demand but have the further merit that they afford relief at the P.O. counter during the ordinary hours of business. (The principle of installing street kiosks was recognised by the National Telephone Company, but at the time of the transfer in 1912 the number was very small owing no doubt to difficulty experienced in securing the consent of local authorities for suitable sites).

The fact that a street kiosk is available at all times for emergency calls to the Police, Ambulance and Fire Stations is very much appreciated, and in several towns the Councils have considered the service so provided sufficient to meet the needs of their districts, and have dispensed with their own street fire alarms.

Hitherto it has been possible to originate local calls only from a street kiosk, but the Department has recently introduced a new type of coin collector, which accepts payments in pennies, sixpences and shillings, and before long the public will be able to originate trunk calls. It has not yet been decided to accept telegrams from call offices in this manner, but that course appears inevitable, and at a not far distant date it should be possible to

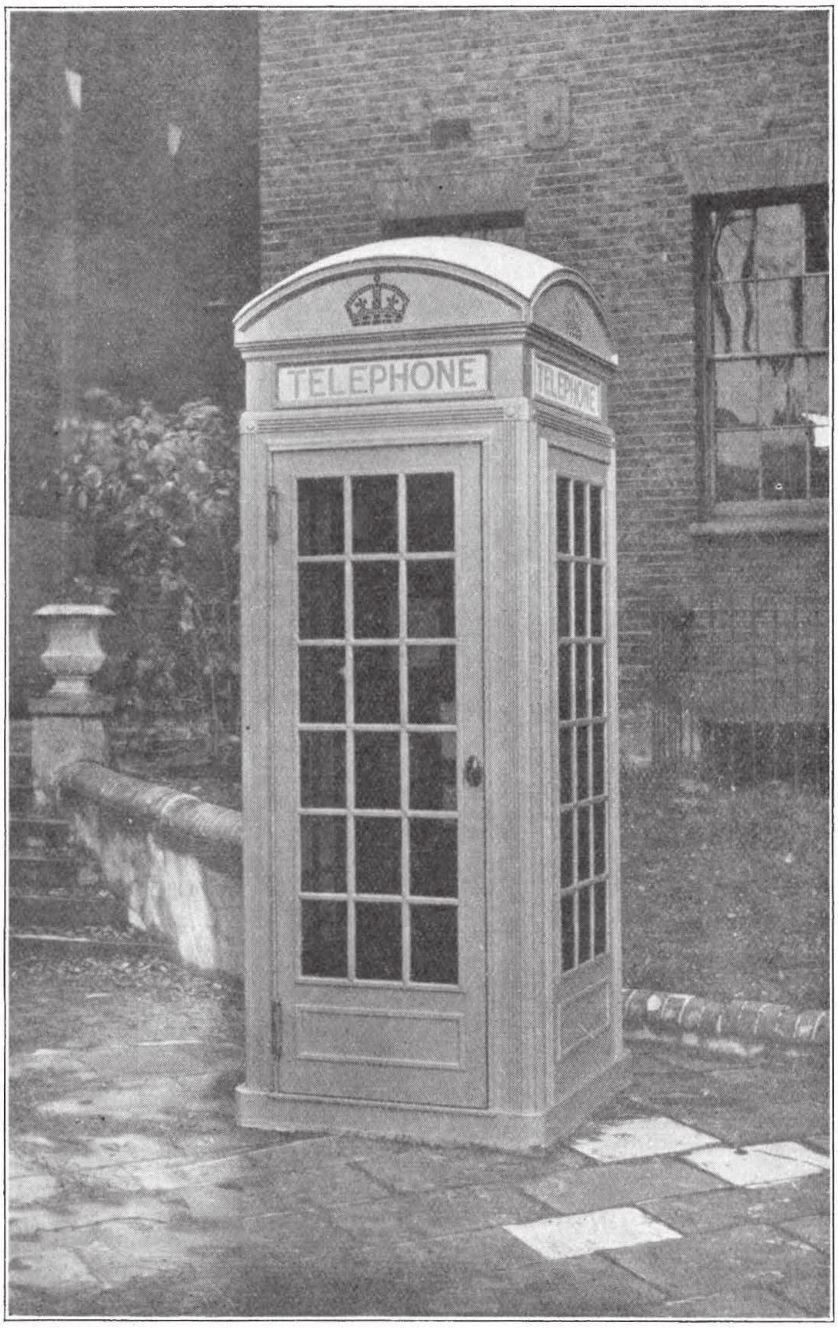


FIG. 1.—CAST IRON KIOSK : DESIGNED BY SIR GILES GILBERT SCOTT, R.A.

telephone a telegram and pay for it at an unattended call office. Such a facility should be of great service in popularising the telegraph service.

The standard telephone kiosk before the War was a wooden structure, but recently a pattern was introduced made of reinforced concrete in flat sections suitable for erection on the site and 1,500 kiosks of this type have been erected throughout the country; these are much more durable and efficient for their purpose than the wooden pattern, but owing to the limitations of reinforced concrete they do not harmonise in all cases with the surroundings.

More recently a number of municipal authorities prepared designs with a view to having a particular type for the streets of their own towns, but as it was considered that a standard kiosk was required which would be architecturally suitable for erection in the main thoroughfares of any large town, it was decided to consult the Royal Fine Art Commission, to whom a number of designs which had been obtained were submitted.

The Commission regarded the designs as inadequate, and suggested that further designs be obtained from architects nominated by the President of the Royal Institute of British Architects. This recommendation was adopted, and as a result the design submitted by Sir Giles Gilbert Scott, R.A., was selected as the most suitable. (Fig. 1). (It is hardly necessary, perhaps, to mention that Sir Giles Gilbert Scott is well known as the architect of the new Liverpool Cathedral and many well-known buildings and War Memorials).

The new kiosk is made of cast iron sections convenient for erection on the site by the Department's workmen, and the TELEPHONE signs are of opal glass with blue letters, illuminated at night by a light fixed to the ceiling.

In the *Post Office Electrical Engineers' Journal* of July, 1921, a description was given of a stamp-vending machine. The service rendered by these machines has been appreciated by the public, and the demand for them has increased to such an extent that machines for the sale of penny and halfpenny stamps have been installed outside 1,000 Post Offices and arrangements are in hand to provide another 500 during the current year. Very considerable numbers of stamps are sold from these machines, the largest number recorded being 13,000 in four days from one pair of machines.

Suggestions have been received from various sources that stamp machines should be associated with P.O. letter boxes, and a design for this arrangement, which should prove very useful outside Post Offices, is under consideration.

As a further development a kiosk with stamp-vending machines, post letter box and telephone was made up recently and erected in one of the main thoroughfares of the City of Bath (Fig. 2). Fitted with the Department's multi-coin Collecting Box a kiosk of this description would provide facilities for the purchase of stamps and posting of letters; the sending of telegrams; the originating of ordinary trunk and local telephone calls; and the summoning of the Police, Ambulance and Fire Brigade.

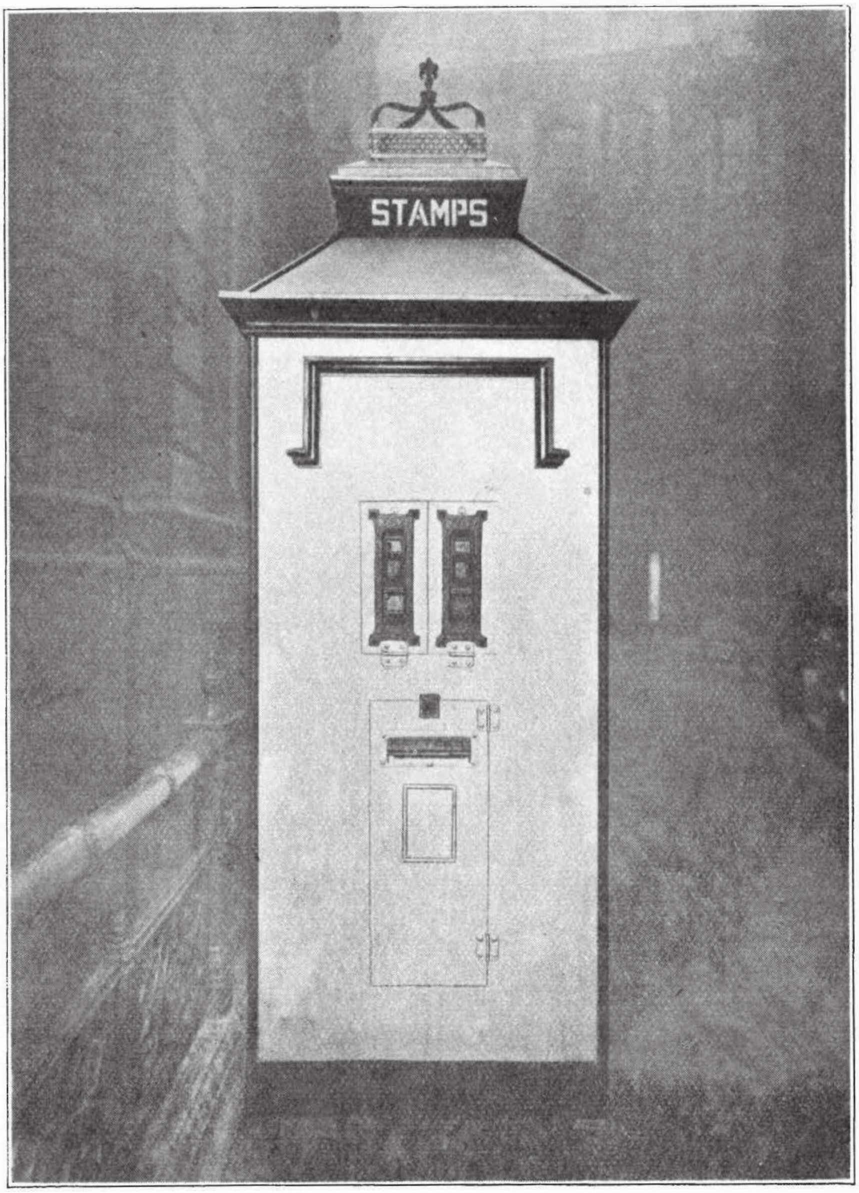


FIG. 2.—THE BATH KIOSK.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT 30TH SEPT., 1925.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
462,964	615	4,187	55,144	461	London	22,718	52,224	1,589,459	48,193
55,895	1,900	19,660	56,068	1,654	S. East	3,797	20,584	92,749	14,206
58,879	4,408	26,096	44,559	1,655	S. West	13,429	5,206	89,784	29,862
46,497	8,480	30,880	40,898	5,332	Eastern	14,222	24,365	49,775	44,671
78,475	8,567	41,416	51,686	3,203	N. Mid.	19,635	35,304	135,237	78,836
56,689	4,814	26,170	56,293	4,401	S. Mid.	12,078	14,714	110,002	83,864
51,089	5,119	28,673	45,065	1,733	S. Wales	5,213	15,756	82,605	64,955
81,642	8,338	23,435	42,474	5,521	N. Wales	11,978	31,811	154,462	46,052
128,440	1,660	17,192	46,829	2,818	S. Lancs.	12,672	61,630	333,746	32,559
77,203	6,306	29,898	42,087	2,513	N. East	8,200	30,005	170,752	25,574
52,044	3,765	23,874	36,127	2,402	N. West	8,732	29,359	100,549	24,897
39,605	2,546	15,458	23,822	2,106	North	3,210	8,456	68,081	45,093
17,999	4,781	6,074	11,619	239	Ireland N.	139	88	28,762	69
53,404	5,569	21,441	32,344	1,153	Scot. East	1,552	8,062	98,584	10,076
74,092	7,464	23,104	39,492	864	Scot. West	12,614	21,581	187,733	23,290
1,334,917	74,332	337,558	624,507	36,055	Totals.	150,189	359,235	3,292,280	572,197
1,311,214	75,807	333,539	618,370	36,782	Figures on 30th June, 1925.	148,219	341,807	3,203,448	543,363

EMPLOYMENT OF PNEUMATIC DIGGING AND ROCK BORING TOOLS ON AERIAL LINE CONSTRUCTION.

MAJOR H. CARTER, A.R.C.Sc., B.Sc., A.M.I.E.E.

INTRODUCTION.

THE application of mechanical methods of excavation to overhead construction has been considered from time to time. Trials of power-driven earth augers have been made, but these machines have been found to be uneconomical under the conditions generally met with in the Post Office Engineering Department. The chief reasons for their failure are :—

(1) Operation is only possible in very easy soil free from rock or stones of any appreciable size.

(2) Due to the fact that, under the ever increasing menace of road widening, it is now usually essential to erect poles in hedge-banks, it is almost always difficult and often impossible, on account of the existence of a ditch or a soft grass margin on the road side of the hedge-bank, to get the machine into position.

This experience led to the conclusion that if any success could be hoped for, the apparatus must be capable of operating in hard and rocky ground, and the source of power would need to be readily applicable to pole sites difficult of approach. It is obvious that any tool capable of cutting a cylindrical hole of the diameter necessary to receive a pole in ground of this nature would require power beyond that capable of provision by a readily portable aparatus, and would require too much setting up to make its employment economical for the depth of hole required. Compressed air, delivered to a small portable tool by flexible hose, seemed to be an ideal manner of fulfilling the second requirement. Years of experience in mine and quarry work have proved the efficacy of pneumatic rock drills and, of recent years, it has been proved beyond question that pneumatically operated paving-breakers are invaluable for breaking up concrete road foundations. Both these cases, however, differ essentially from the one under consideration, in that work of one type only is encountered and that work is continuous, comparatively little movement of plant being required. In pole hole work, on the other hand, it is the exception to get long stretches where every hole is in rocky ground. Due to the fact that holes are required at 50 to 60 yard intervals, adjacent excavations may vary widely in character, also the time spent in moving the plant from hole to hole compared with the time the equipment is actually working, becomes an important factor. To meet the conditions of our work, it was obvious that a very portable outfit comprising a variety of tools capable of excavating under widely varying conditions, was required. Negotiations were accordingly opened with the Ingersoll Rand Co. Ltd., who have a world-wide reputation as manufacturers of mining machinery, and as a result it was decided to make a trial of the equipment described in detail below. The building of the Inverness-Wick trunk line presented itself as a particularly suitable field for the trial, as it was understood that a large amount of difficult and costly digging was likely to be encountered on this work.

DESCRIPTION OF THE EQUIPMENT.

Compressor. (Fig 1).—This consists of a $4\frac{1}{4}'' \times 4''$ vertical two-cylinder, single-acting air compressor driven by a four-cylinder four-cycle petrol engine of about 12 B.H.P. Both compressor and engine are water cooled. The compressor is capable of delivering 60 cub. ft. of air per minute and works at a pressure of 100 lbs. per square inch. A governor, operated by compressed air, is provided which cuts down the petrol supply to the engine during unloaded periods when the air has reached the standard pressure. The whole is mounted on a cast steel frame, which is fitted to a Ford one-ton chassis in order to secure the maximum degree of portability. Four large oak boxes are fitted to the

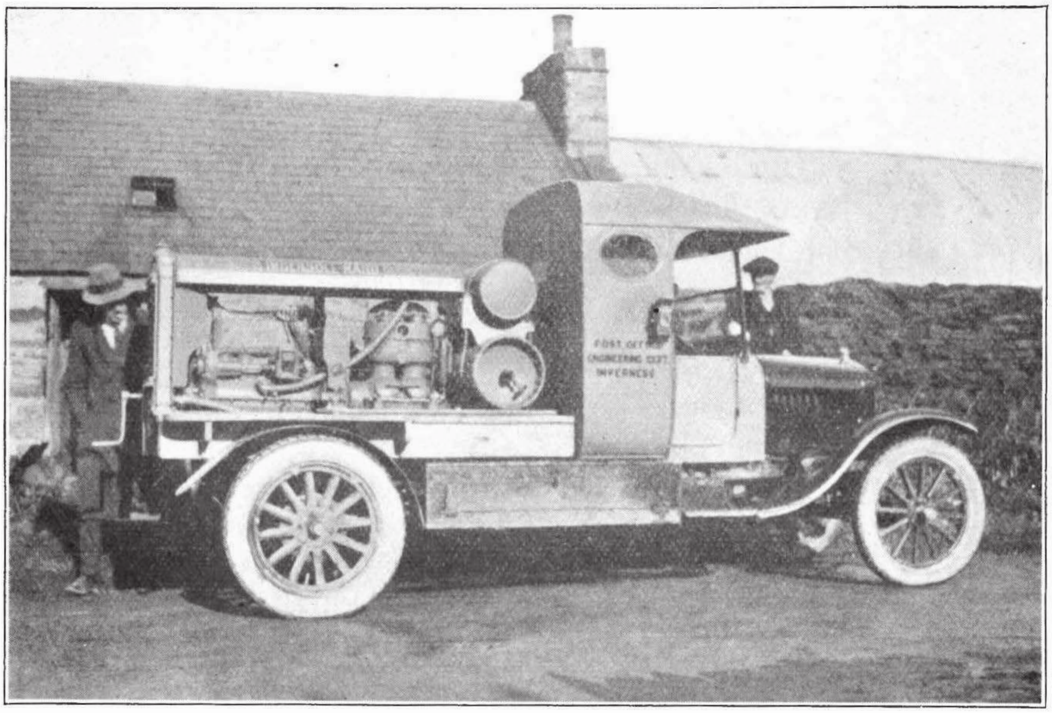


FIG. 1.—THE POWER EQUIPMENT.

chassis, two on each side, in order to accommodate pneumatic tools, drill and paving breaker steels, and small tools for the engines and compressor. A strong wooden shelf is also built over the wings to form a bench for working on the tools and to protect the wings when getting out and putting away tools. Two 50-foot lengths of armoured air hose are provided for supplying compressed air to the tools.

Rock Drill.—This is the firm's Jackhammer Type B.C.R. 430 and weighs 45 lbs. It operates a hollow steel, with four point cross bit, capable of drilling holes 60″ in depth. The shank of the steel is struck by the mechanism of the jackhammer and in addition the steel is rotated. A portion of the exhaust air is led through the drill to the face of the work for clearing away the cuttings from the hole. To meet unusual conditions where greater blowing capacity is required, an exhaust valve is provided which may be turned so as to divert the whole of the blast through the drill. For drilling a hole 60″ in depth three steels are used, their

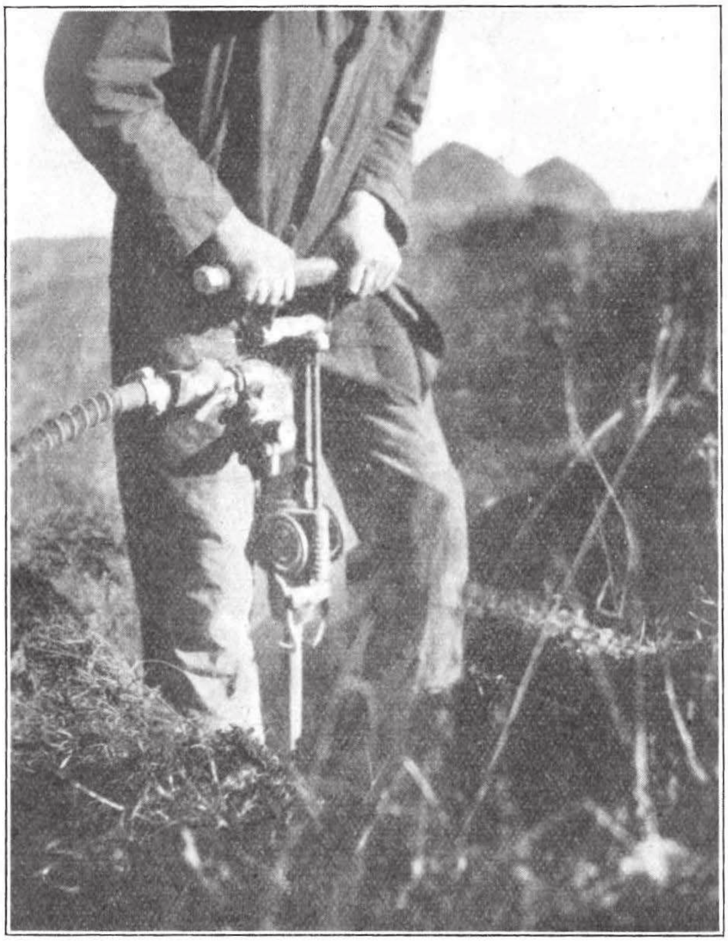


FIG. 2.—JACKHAMMER TYPE B.C.R. 430.

lengths being 20", 40" and 60", the finished diameter of the hole being $1\frac{1}{8}$". The jackhammer in operation is illustrated in Fig. **2**.

Paving Breaker. (Fig. **3**).—This is a tool with which all town dwellers are now becoming familiar due to the operations of contractors breaking up concrete road foundations. The machine used is the firm's type C.C.25, which weighs 69 lbs. Its operation is similar to that of the jackhammer with the exception that the steel does not rotate and there is no air blast for clearing away the cuttings. It is intended for breaking up rock or hard material by impact and not for drilling a hole. Solid hexagon chisel bits $1\frac{1}{4}$" are provided, in addition to a flat chisel bit with a blade 12" long by 3" wide.

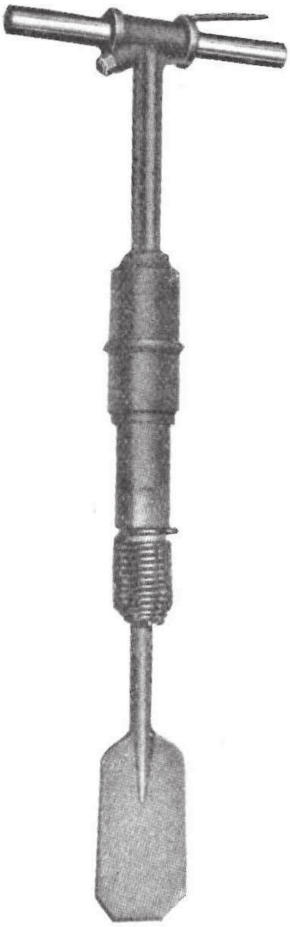


FIG. **4**.

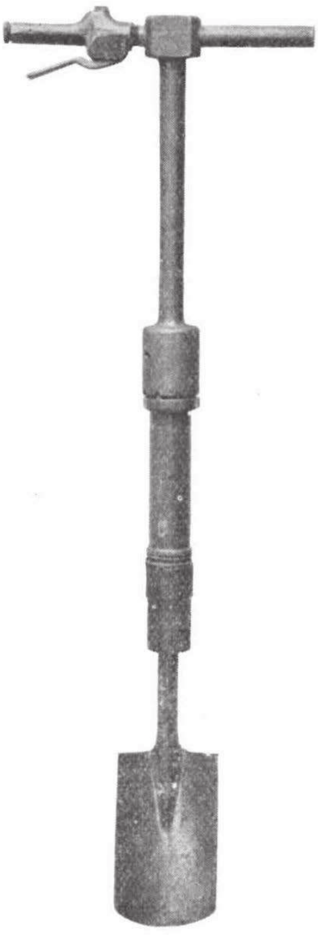


FIG. **5**.

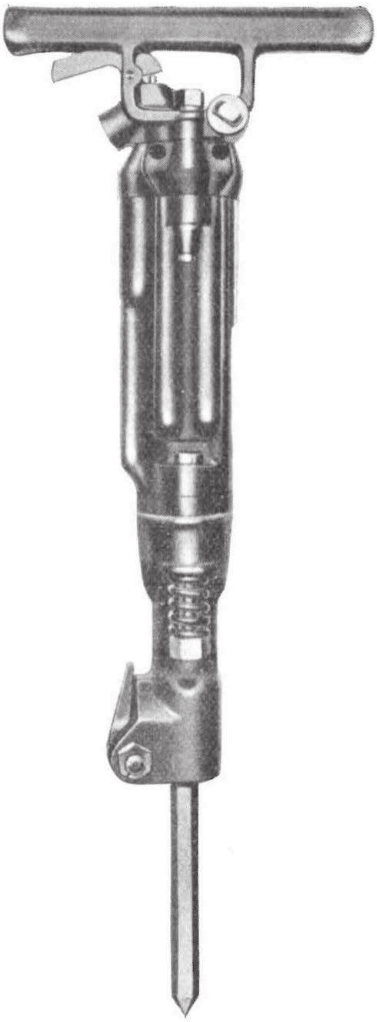


FIG. **3**.

Trench Diggers.—Two trench digging tools, known as the 156 H and the 158, are provided. The former (Fig. **4**), which weighs 29 lbs., is for use in hard clay or where light picking is required. It is shown in operation in Fig. **6**. The latter (Fig. **5**) weighs 45 lbs. and is for work in shale or hard material beyond the power of the 156 H digger, but not sufficiently difficult to necessitate the use of the C.C. 25 (paving-breaker).

Description of Trials.

The machine was first brought into operation on the Black Isle, near Inverness, where nine rock holes had been left by the gangs. It was found that this rock was not solid; the rock drills penetrated it at the rate of about two feet per minute and the firing of a blasting charge in the drill holes produced little result on the surface. The paving-breaker was accordingly used and was found to be very well adapted for work in the hard shale and conglomerate which was encountered. One and a half working days completed this work.

Fig. **6**.—Trench Digger 158 in Operation.

The equipment was then despatched to Wick, in the neighbourhood of which most of the difficult excavation was expected. For many miles south of Wick, a hard blue rock known as "Caithness Flag" abounds. This is usually met with at from one to three feet below the surface, and whilst much of it is solid, in many cases it was found that holes had to be dug entirely in hard shale.

A permanent crew of two men was allotted to the machine. One of these was the driver of the Ford, who was also given care of the compressor engine, compressor and pneumatic tools. The other man was a qualified blaster. Both men were instructed in the use of the pneumatic tools under the capable direction of Mr. J. R. Lomax, of the Ingersoll Rand Co., who spent three weeks with the equipment. The Department was particularly fortunate in securing his services and the operators, Messrs. Milne and Crawford, quickly became proficient in the use of the outfit and began to take a pride in their tools and the special nature of their work. Arrangements were made for the equipment to work five days per week, the Saturday being spent on overhaul. It was found that the best way to employ the outfit was to allow the soft surface soil to be dug by the normal working party and then to complete the holes by the pneumatic tools. In the case of holes in shale or hard clay, no further assistance was given by the gangs. The operators used the tools and cleared out the broken material by hand shoveling. In the case of rock holes two or more men, as required, were taken from the gangs to clear out the holes after blasting. Gelignite with time fuses was used for blasting, and when a succession of solid rock holes was encountered, the blaster was chiefly occupied in preparing and firing his charges, the drilling being mostly done by the driver.

The tools were all found to work very well in the types of material for which they were designed. The only difficulty experienced with the paving-breaker was that of handling it on account of its weight. Its operation is considerably more difficult in a hole than on a level road surface due to the confined space, and the fact that the tool has frequently to be lifted in and out of the hole.

A slight difficulty was occasionally experienced through the air hole of the drill steel becoming choked with gravel, which sometimes occurred in the seams between the layers of rock. The drills will not work when they are unable to clear themselves. This difficulty diminished as the operators became more experienced in the use of the exhaust valve previously referred to.

The trench diggers were found to be very convenient for shaping down the sides of the holes.

The Ford mounting was found to be a most essential factor in the success of the machine. With its tool boxes it forms a complete unit and the equipment can be transported from the garage to the work very quickly and operations commenced in from five to ten minutes after arrival. Practically no time is wasted in moving from one hole to another. Three gangs were working in the twelve miles between Wick and Lybster and the machine was sent to one or other of these gangs for a day as the state of the work required.

RECORD OF PERFORMANCE.

Over a period of several weeks, it was found that the equipment, working five days per week, was capable of getting out over 30 holes per week, and was able to do all the hard digging for the three gangs referred to. In addition to erecting the new line, these gangs were also cutting out and recovering the old telegraph line, hence their erecting operations were considerably retarded. It should also be mentioned in passing that in recovering the old poles they were finding Simplex Pole Jacks of immense value.

A good financial comparison can be obtained from a study of the work performed on October 12th, which is representative. This was as follows:—

Holes completed	6	5 by drilling and blasting. 1 by C.C. 25 and 156 H.
Employed with machine ...	2 men.	
Equivalent of annual charges and running costs of equipment ...	2 men.	
Assistance from gangs ...	2 men.	
Total	6 men.	

Time taken 8 hours.

Average man-hours per hole ...	8	(exclusive of cost of blasting materials).
Estimated man-hours per hole by manual methods	20	do. based on average of 20 similar holes in the neighbourhood.

Saving per hole 12 man-hours or 15/6, *i.e.*, a saving of £4 13s. 0d. on the day's work.

Another interesting day's work was that of October 14th, when 12 holes were completed by drilling and blasting, entailing a total drill of 60 ft. The average rate of drilling in solid rock was 4 inches per minute. It is estimated that to drill this amount by hand jumper and clearing spoon would have occupied three men for eight days.

CONCLUSIONS.

In the circumstances in which the equipment has been used so far, there is no doubt that very considerable saving can be effected. It must be admitted, however, that difficult digging is being encountered over abnormally long stretches. The possibility of keeping such an outfit employed continuously is the factor which must determine whether its introduction generally into the Post Office service will be eventually economical. Although so far there has been no chance of comparing its performance with manual labour on less difficult excavation, there is good reason to suppose that the trench diggers will do the work more economically wherever pick work is required, though there is no doubt that the saving will be much less than in cases where the paving-breaker or the jackhammer is employed. It is no overstatement to say that there are large areas throughout the country where very few holes can be got out by means of a spade alone. The extreme portability of the machine enables it to operate as required where conditions are most suitable throughout an Engineering District, and it is probable that other work besides pole work can be found for it. Small underground schemes or small trenching works through concrete road foundations, which would ordinarily be given out to contract, present themselves as a possible field. It is probable that a pneumatic winch can be obtained which will be suitable for pulling in medium-sized cables, and work of this nature might be found to fill in periods when the equipment might otherwise be unemployed.

On the whole, it is felt that further experience will show that the supply of further sets to certain selected Districts will be amply justified.

TWO INTERNATIONAL CONFERENCES AND THE INDUCTIVE INTERFERENCE PROBLEM.

By S. C. Bartholomew, M.I.E.E.

The International Conference on Large Electric High Tension Systems held its Third Session in Paris this year, from June 16th to 25th, and I was privileged to attend as a Member of the Committee looking after the interests of Great Britain. Not quite coincident in time with this Conference, another was held in the same neighbourhood—that of the Comité Consultatif International des Communications Téléphoniques à Grande Distance (International Advisory Committee on Long Distance Telephony in Europe, usually referred to as the C.C.I.), which was in session from June 22nd to 30th, and on which I was a delegate of the British Post Office for the purpose of dealing with the subject of the "Protection of telephone lines against disturbing influences from strong currents and high tension power installations." This subject formed a connecting link between the two Conferences and considerable prominence was given to it at the Power Conference, the matter taking up nearly the whole of one of the six days devoted to work. The Power Conference had presented to it papers dealing with various aspects of the problem, the principal contributions being that of M. Valensi, the Secretary-General of the C.C.I., which dealt with the matter very clearly and thoroughly from the telephone point of view, and that of M. Brylinski, of the Professional Syndicate of Producers and Distributors of Electrical Energy, who dealt with the matter as a power engineer. The main consideration, however, was the attitude to be adopted towards certain "Directives" (guiding principles) which had been drawn up by a Sub-Committee of the C.C.I. and which were to be submitted for the consideration of the full Telephone Conference during the following week. These "Directives" are a serious attempt to draw up rules concerning means to be adopted to protect telephone lines against disturbing influences from strong currents or high tension power installations, and they were placed before the Power Conference in their tentative form and commented upon by M. Brylinski, who was to attend the Telephone Conference on certain days as head of a delegation from the Power Conference.

Following the reading of the papers a discussion took place, which was somewhat animated. Signor Guido Semenza (Italy), Mr. Faccioli (U.S.A.) and Mr. E. B. Wedmore (British Electrical and Allied Industrial Research Association) were the principal power engineers who took part, whilst M. Milon (President of the C.C.I.) and I spoke from the telephone point of view. At the conclusion the Power Conference decided not to give a definite approval of the proposed Directives, but indicated that it concurred in the course suggested by M. Brylinski, namely, that he, as head of the power delegation attending the Telephone Conference, should press for the limitation of the proposed rules to power lines worked at 60,000 volts and over and that for lower voltages the limits laid down should be reduced.

M. Brylinski is a gentleman of strong personality and, when really "under way" and enforcing an argument, speaks so rapidly that only the very best linguists can follow him. This did not matter so much at the Power Conference, where the proceedings were conducted in both French and English and very able engineer-interpreters were employed, but at the Telephone Conference, where the proceedings were entirely in French, his arguments were frequently difficult to follow.

In addition to the engineers from the Power Conference, delegates from the International Union of Railways also attended the C.C.I. Conference to discuss the "Directives": these delegates were engineers from the French, Swiss and Italian Electric Railways.

During the course of the Conference, the "Directives" were modified in some respects and the power and railway delegates, who attended four of the sessions and were given every facility for expressing their views, regarded many of the amendments as worsening the conditions so far as their interests were concerned, and finally they presented a statement which indicated that, whilst generally in agreement with the method of tackling the problem and the limits laid down, they considered some of the conditions could not always be complied with—for instance, where the physical conditions are unfavourable, as in passes through mountainous country, it was stated that it would be economically impossible to provide the required separating distances.

The proposal to limit the "Directives" to power systems worked at pressures of 60,000 volts and over was not agreed to by the Telephone Conference.

A word now as to the scope and contents of the "Directives.' The original rapporteurs were Dr. Breisig (Germany), M. Muri (Switzerland) and Prof. Di Pirro (Italy), but undoubtedly the basis of many of the rules and the formulæ can be attributed to experience and investigations in Germany. Some of the formulæ are derived from first principles, but others, such as those dealing with interference from electric railways, have factors which have been obtained empirically. The tentative proposals drawn up in November, 1924, were modified to a certain extent as a result of criticism by the various administrations and by the work of a Sub-Committee.

The scope of the "Directives" can best be expressed in the words used in their introduction:—

> In nearly all countries with well developed telephone systems it has been found that the working of telephone circuits suffers from the disturbing influence of neighbouring power lines. On account of future developments which doubtless will take place in power distribution lines and electric traction, progressive diminution in the quality of telephonic transmission and an increase in the danger to the personnel and telephone plant is to be feared if measures are not taken immediately to prevent interference to the telephone service by power installations. These measures relate to:—
>
> (1) Telephone lines.
> (2) Power lines and installations.
> (3) The proximity (parallelism) of power lines to overhead telephone lines.
> (4) The proximity (parallelism) of power lines to underground telephone circuits.

Although it is relatively simple and beyond discussion to

> lay down in detail, even at the present time, the principles governing the major part of the technical regulations to be adopted, it is not generally possible to fix exactly the limits within which these regulations may be carried out. Any further contribution to the study of the phenomena of electromagnetic and electrostatic induction, as well as any progress made in the construction of telephonic and industrial material and any modification in the normal conditions of exploiting telephone lines and high power lines, would, therefore, involve a revision of the figures proposed.
>
> Nevertheless, it appears to be useful, even at the present time—in order to fix ideas on the subject—to give certain numerical data of a precise character with regard to the limits within which the technical regulations recommended should be applied, with a view to preserving a certain degree of efficiency. It is in this spirit that the numerical conditions laid down in the text of the " Directives " have been determined.
>
> On the other hand, the " Directives " should be regarded only as the expression of the opinion common to the technical experts who are taking part in the work of the C.C.I. Questions of an administrative or economic nature relating to the problem of the proximity of power lines are not within the competence of the Committee and have been left aside.
>
> In particular, the Committee has abstained from entering into details of the rules of procedure which Telephone Administrations and the services engaged in the production or distribution of electricity should follow in their mutual relations. The Committee thinks, however, that it is able to make a very general recommendation.
>
> In order to obtain the most advantage from the measures to be taken for the protection of telephone lines and in order to facilitate their practical application, it is desirable that the telephone or telegraph services concerned should evince the utmost goodwill by way of collaboration. Systematic and regular exchange of all useful information relating to the construction of existing or proposed lines and to changes in the conditions of working of installations in proximity, either at the present time or in the future, is much to be desired.

The accompanying chart shows graphically the main recommendations of the " Directives " as finally approved, but it would perhaps be well to indicate the nature of the work. The main rules are embodied under the four general headings given in the foregoing extract and, in addition, there are six appendices, some with supplements, which show how the formulæ employed are arrived at and the methods of calculating the limits fixed in the general rules. The scope of the appendices is indicated by their headings, namely :—

Appendix I. Determination of the symmetry to earth of trunk telephone lines.

Appendix II. Examination of the conditions under which proximity may be permitted between symmetrical high tension power lines, polyphase or single-phase, not connected with earth at any point, and telephone lines.

Appendix III. Proof with reference to the margin of proximity allowable between telephone lines and three-phase or single-phase high tension alternating current lines which have an earthed neutral point.

Appendix IV. Determination of the degree of permissible proximity (parallelism) between alternating current single-phase railways and three-phase railways with earth returns, on the one hand, and telephone lines on the other hand.

Appendix V. Measurement of noise induced in telephone circuits.

Appendix VI. Determination of the unbalance of telephone circuits with reference to disturbing lines.

In the body of the " Directives," in addition to general recommendations as to the layout and working of power and traction systems, definitions are given of allowable limits of deformation for the pressure waves of alternators, harmonics in alternating current and direct current supplies, magnetising currents of transformers, etc.

The two most controversial points in the proposals related to " acoustic shock " and " permissible interfering noise," or, more shortly, " allowable noise." The former has become a matter of very serious concern in some parts of the Continent and in America, the effects being usually produced by transient faults on overhead power systems and, if of frequent occurrence, have a demoralising effect on the nerves of operators who are subjected to them.

" Acoustic shock " occurs on telephone circuits when the voltage of the wires to earth is raised to such a value that the lightning protectors should function and only one operates : when this occurs, the pressure applied to the terminals of the receiving apparatus becomes equal to the pressure between the wires and earth, which produces a great increase in the current through the receiver, causing the diaphragm to make violent contact with the pole pieces and resulting, therefore, in a violent or brutal noise. The excessive voltage on the telephone circuit may be caused either by a momentary unbalance of pressure on a neighbouring power line or by the inductive effects of the current in such a system when it is unbalanced by the occurrence of a short circuit to earth, etc. The former is the more usual cause and is associated with power systems working with an unearthed neutral point: on such a system the occurrence of an earth fault causes a change in the electric field, a travelling wave is set up which produces a corresponding effect upon neighbouring telephone circuits, and earthing of the telephone lines through the lightning protector causes the discharge through the telephone receiver of the condenser constituted by the wires of the telephone circuit and the earth. It is agreed that the worse effects are produced by the closing of a switch on a power system when the contacts of the different phases are not made simultaneously and when, moreover, there is an earth fault on one of the lines. The effects may be only of a momentary character, but if the fault is what is known as an "arcing ground" then the trouble will persist.

In order to avoid danger from acoustic shock either the telephone wires must not be subjected to a voltage higher than the breakdown voltage of the lightning protectors, usually taken at 300 volts, or, if the wires are within a zone in which that voltage can be induced, the condenser formed by the telephone wires and earth must not during its discharge release sufficient energy to cause a dangerous shock. The danger zone, from this standpoint, can be shown to be that bounded by a telephone line and a line parallel with it at a distance $a_1 = \frac{1}{3}\sqrt{E}$, where a_1 is in metres, and E the voltage of the power line. If a power line and telephone line run parallel within this zone, the proximities should be so restricted that the electrical energy which acts in the telephone circuit due to the sum total of all proximities will not exceed 1/50th joule. In the most unfavourable case, *i.e.*, where the the telephone line is not longer than the parallelism, the whole of the energy might produce its full effect at one end of the line; but in all other cases the interference wave is divided, the two portions flowing to the ends of the circuit, where they arrive more or less attenuated according to the length of the path traversed—it is taken, therefore, that on the average only half the energy reaches the telephone receiver.

To determine whether the permissible value of the induced energy is exceeded, a "characteristic coefficient of exposure to danger" is employed, namely:—

$$f = \frac{lV^2}{Z+2}$$

in which

l = length of proximity in kilometres.

Z = number of wires in the system to which the telephone circuit belongs.

$$V = \frac{E}{400} \cdot \frac{bc}{a^2 + b^2 + c^2} pqr$$

and

E = working voltage of the high tension system (expressed in volts).
a = distance, in metres, between the two lines.
b = average height, in metres, of the high tension line above ground.
c = average height, in metres, of the telephone circuit above ground.

p, q and r are factors expressing the effect of the voltage drop (screening effect), due to neighbouring earthed bodies of the following values:—

In the case of an earth wire running the whole length of the system (lightning protector) $p = 0.75$.

In the case of a continuous row of trees in close proximity to the high tension line $q = 0.7$.

In the case of a continuous row of trees in close proximity to the telephone line $r = 0.7$.

In the two last cases the distance between the row of trees and the line is assumed not greater than 3 metres.

In the absence of earthed bodies of this kind, the corresponding factors, p, q, r, should be expressed by unity.

When the high tension lines are carried on poles more than 120 metres apart b may be taken as 12; in other cases generally $b = 8$.

The height of the telephone circuits, c, is usually taken as being equal to 6.

The characteristic coefficient of exposure to danger, f, should be determined separately for each of the sections within which the distance between the lines remains fairly constant. If p, q, r or Z varies in any one zone, the length of proximity should be suitably sub-divided and the characteristic coefficient of exposure to danger should be determined separately for each part of the line. Crossings do not enter into consideration.

The telephone circuit should be regarded as exposed to danger when the sum of the characteristic coefficients of exposure to danger exceeds 50.

When the high tension line has a voltage applied to it by means of an interrupter of low power or by means of other plant capable of eliminating transitory waves, the sum of the coefficients of exposure to danger should not exceed 100.

The bone of contention in the matter was the definition of allowable acoustic shock as that produced when an energy of 0.01 joule is applied to a telephone receiver. Many engineers question whether this figure is not too high. M. Valensi had apparatus fixed at both the Power Conference and the Telephone Conference which appeared to bear this out. The matter is not yet settled, however, as it is down for further consideration at the next Conference, and, in the meantime, investigations are being made with the object of finding a better definition. Experiments go to show that energy ($\frac{1}{2}CV^2$) is not the proper basis, as, with the same energy, the effect is greater with a low voltage and large capacity than with a high voltage and small capacity.

The question of allowable noise produced by inductive interference was also a matter on which there was not unanimous agreement. The definition in the case of overhead lines reads:—

> "Interference to telephone working occurs when a power line develops, between the conductors of the telephone circuit, a voltage equivalent (as regards the intensity of noise in the telephone receivers) to an alternating voltage greater than 5 millivolts at a frequency of 800 periods (5000 radians per second)."

In the case of underground telephone circuits, the voltage is reduced to 2 millivolts. Here again the allowable noise appeared to many to be excessive, as demonstrated by the actual practical experiments on apparatus provided by the French Administration engineers. Noise measurements are not an easy matter to carry out, even when there is an agreed basis of comparison. Both the Standard Telephones and Cables, Ltd. (late Western Electric Co.) and Messrs. Siemens & Halske manufacture noise measuring sets, but these differ fundamentally, the former employing as a source of artificial noise a buzzer giving a complex wave form, whilst the latter uses a buzzer in which the frequency is maintained constant, *i.e.*, 5000 radians per second (frequency 800 per second). The actual methods employed for comparing the noise to be measured with that produced by the measuring set do not differ materially, the Standard set giving results in certain arbitrary noise units, whilst with the Siemens-Halske apparatus the readings are in millivolts on a potentiometer. As in the case of acoustic shock, further study is being given to this question by the various Administrations.

Another question which caused controversy and which was considered under the heading of "danger," was that of the limits to be allowed for the longitudinal voltage induced by electric traction systems (single-phase and three-phase) in telephone circuits by the normal working of the railways, *i.e.*, with maximum loads. This was finally fixed at 60 volts (effective) with an extension to 100 volts in cases where the circumstances are exceptional and normal clearance cannot be obtained owing to the presence of obstacles.

The electromagnetic inductive effect (longitudinal voltage) produced during the short time required for the actuating of a circuit breaker of a power line normally earthed at the neutral point, or of a single-phase or three-phase electric traction line suddenly and accidentally earthed, was fixed at a maximum of 300 volts (effective). (No rule was made to cover similar happenings on traction systems working with continuous current, as it may be expected that by reason of the short duration of the faults they are not likely to cause danger to neighbouring telephone lines.) The following formula, which indicates the degree of danger, g, provides a means of verifying that the limit of 300 volts is not exceeded:—

$$4 \times 10^{-3} \frac{Ik\, l\omega}{\sqrt{a}} = g$$

where

Ik indicates the short-circuit current in amperes.

l indicates length of the proximity in km.

ω is the frequency of the currents in the high tension line × by 2π.

a is the distance between the parallel lines in metres.

The above equation is applicable only to low frequencies up to 60 p.p.s. (approximately).

It is not possible at the present time to give the formula for calculating the coefficient when the lines are further apart than 1000 metres.

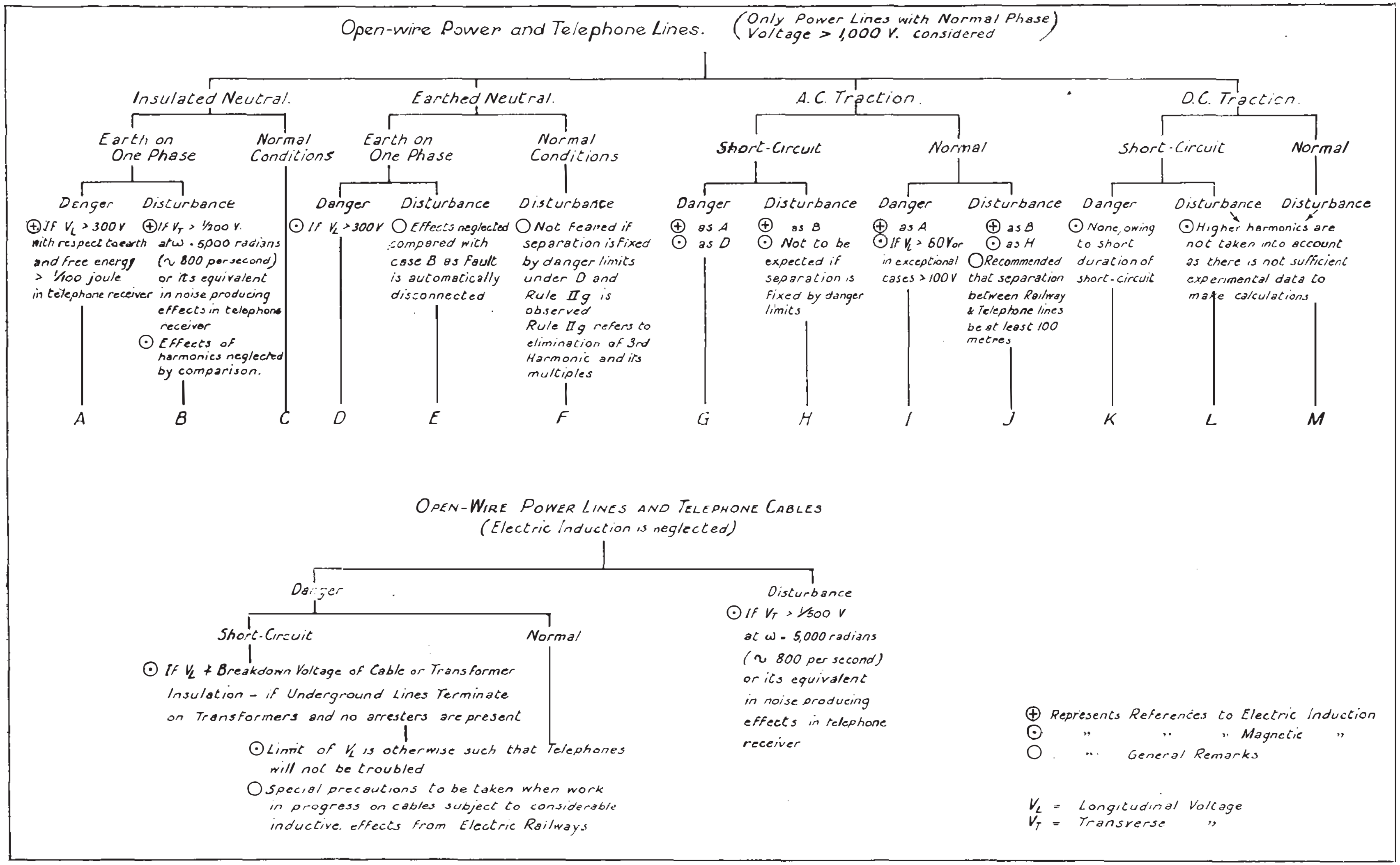
The factor Ik presents a difficulty as it is not an easy matter to arrive at the figure where the power system network is complicated.

The characteristic coefficient g of exposure to danger should be calculated separately for each section within which the distance between the lines is more or less uniform and the telephone lines should be regarded as exposed to danger if the sum total of all the characteristic coefficients of exposure to danger exceeds 300 volts. Crossings are not included in the calculation.

In a short article it is not possible to indicate all the points dealt with in the "Directives," and those interested in a closer study must await the publication of the full text; but it should be observed that the "Directives" are not concerned with telegraphs, the C.C.I. activities being limited to long-distance telephony. Further, that the British Post Office has not yet given them unqualified approval as it is considered that some of the limits are not satisfactory from a telephone point of view.

The chart printed with this article summarises the main conclusions. It follows a method of presentation used by Dr. Stanley Parker Smith, who is now engaged in preparing a report on the inductive interference problem on behalf of the British Electrical and Allied Industrial Research Association.

A few comments on the Conferences may not be out of place.


Open-wire Power and Telephone Lines. (Only Power Lines with Normal Phase Voltage > 1,000 V. considered)
Insulated Neutral.
Earthed Neutral.
A.C. Traction.
D.C. Traction.
Earth on One Phase
Normal Conditions
Earth on One Phase
Normal Conditions
Short-Circuit
Normal
Short-Circuit
Normal
Danger
⊕ If V_L > 300 V with respect to earth and free energy > 1/100 joule in telephone receiver
A
Disturbance
⊕ If V_T > 1/200 V. at ω = 5000 radians (∿ 800 per second) or its equivalent in noise producing effects in telephone receiver
⊙ Effects of harmonics neglected by comparison.
B
C
Danger
⊙ If V_L > 300 V
D
Disturbance
○ Effects neglected compared with case B as Fault is automatically disconnected
E
Disturbance
○ Not feared if separation is fixed by danger limits under D and Rule IIg is observed
Rule IIg refers to elimination of 3rd Harmonic and its multiples
F
Danger
⊕ as A
⊙ as D
G
Disturbance
⊕ as B
⊙ Not to be expected if separation is fixed by danger limits
H
Danger
⊕ as A
⊙ If V_L > 60 V or in exceptional cases > 100 V
I
Disturbance
⊕ as B
⊙ as H
○ Recommended that separation between Railway & Telephone lines be at least 100 metres
J
Danger
⊙ None, owing to short duration of short-circuit
K
Disturbance
Disturbance
⊙ Higher harmonics are not taken into account as there is not sufficient experimental data to make calculations
L
M
OPEN-WIRE POWER LINES AND TELEPHONE CABLES (Electric Induction is neglected)
Danger
Disturbance
⊙ If V_T > 1/500 V at ω = 5,000 radians (∿ 800 per second) or its equivalent in noise producing effects in telephone receiver
Short-Circuit
Normal
⊙ If V_L ≯ Breakdown Voltage of Cable or Transformer Insulation – if Underground Lines Terminate on Transformers and no arresters are present
⊙ Limit of V_L is otherwise such that Telephones will not be troubled
○ Special precautions to be taken when work in progress on cables subject to considerable inductive effects from Electric Railways
⊕ Represents References to Electric Induction
⊙ " " " Magnetic "
○ " General Remarks
V_L = Longitudinal Voltage
V_T = Transverse "

Comité Consultatif des Communication Téléphoniques à Grande Distance: Paris, June, 1925; showing chief features of the Directives (Guiding principles). Most unfavourable conditions are considered when fixing limits.

The point that impressed one most was the fact that the interference problem is not now confined to the mutilation of signals and speech, the main consideration being the question of danger to personnel. It transpired that one of the telephone administrations had at one time very serious staff difficulties owing to the effects of acoustic shock upon operators. Various devices are now provided, however, which lessen these effects. Further, two cases were mentioned of telephone linemen being killed by inductive effects due to the occurrence of faults on overhead high pressure lines where the power system and the telephone line were in close proximity. The power systems concerned were operated with unearthed neutrals and earth faults occurred simultaneously on two phases. There are very few systems in Great Britain where the unearthed neutral is employed, it being standard practice here to work with neutral earthed either directly or through a low resistance. In one of the fatality cases the lineman was killed whilst at work on a telephone line in Italy, but the actual fault on the power line was in Switzerland, the telephone route being one connecting the two countries.

As pointed out previously, the Power Conference proceedings were conducted in both English and French, interpreters being employed, when necessary, in the reading of the papers and in the discussions. Many of the engineers present could speak both languages fluently, however, and all could follow the proceedings with ease. The papers were also printed in both languages, and here one sometimes noticed in parts a little vagueness which became clearer on closer investigation. The statement that certain apparatus should be "well insulted" is near enough, but the following sentence is more than clear as it conveys, in striking language, what is likely to happen :—

"By having a finger on this hardware the operator is protected from small discharges static which might otherwise break his equilibrium when he gets in contact with the tower."

To be privileged to attend an International Conference of this character is an unique experience. 25 countries were represented and there were present over 200 of the principal power engineers of the world. The hospitality of the French Committee responsible for the arrangements was most generous and was greatly appreciated. As a Member of the British Committee, I had the honour of being one of the delegates presented to the President of the French Republic (M. Doumergue) at the Elysée Palace when representatives from the various countries were received there. There was, of course, great personal gratification in this, and I could not help feeling that my presence there, as a communication engineer, illustrated in a very practical way the broad views and spirit of co-operation of the British power engineers, in including me in the delegation.

THE THEORY OF LADDER NETWORKS.

By the Research Staff of the General Electric Co., Ltd.
Work conducted by A. C. BARTLETT.

THE theory of a ladder network such as that shown in Fig. 1 has been dealt with previously in this journal by H. P. Few[*] as a special case of a more general result.[†]

The whole theory of current and voltage distribution through the network can, however, also be put into very compact form if treated from the point of view of continued fractions and simple continuants.

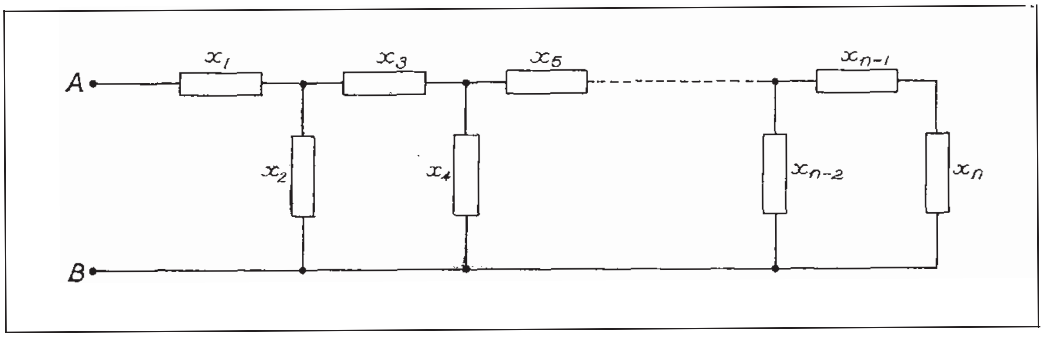


FIG. 1.—THE THEORY OF LADDER NETWORKS.

A simple continuant $K(a_1, a_2, a_3 \ldots\ldots\ldots a_n)$ may be defined by the following properties[‡]:—

$$K(0) = 1$$

$$K(a_r) = a_r$$

$$K(a_1, a_2 \ldots\ldots\ldots a_n) = a_1 K(a_2, a_3 \ldots\ldots\ldots a_n) + K(a_3, a_4 \ldots\ldots\ldots a_n)$$

Thus

$$\begin{aligned} K(a_1, a_2) &= a_1\, K(a_2) + K(0) \\ &= a_1\, a_2 + 1 \\ K(a_1, a_2, a_3) &= a_1\, K(a_2, a_3) + K(a_3) \\ &= a_1(a_2\, a_3 + 1) + a_3 \\ &= a_1\, a_2\, a_3 + a_1 + a_3 \end{aligned}$$

Simple continuants are related to continued fraction by the relation

$$a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \ldots\ldots \\ + \cfrac{1}{a_n}}} = \frac{K(a_1, a_2 \ldots\ldots\ldots a_n)}{K(a_2, a_3 \ldots\ldots\ldots a_n)}$$

---

[*] H. P. Few. Vol. 15, p. 92.

[†] Fleming. Phil Mag., Sept., 1885.

[‡] Chrystal Algebra II., Chap. XXXIV.; also Muir Treatise on Determinants, 1882, Chap. III,

Returning now to the network which is constructed of series elements x_1, x_3, etc., and shunt elements x_2, x_4, etc., let the impedances of the elements x_1, x_3, x_5, etc., be a_1, a_3, a_5, etc., and the impedances of the shunt elements x_2, x_4, etc., be $\frac{1}{a_2}$, $\frac{1}{a_4}$, etc.

Then the sending end impedance of the network will be given by the continued fraction

$$a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \dotsb \cfrac{}{\dotsb + \cfrac{1}{a_n}}}}$$

which is equal to

$$\frac{K(a_1, a_2 \dots\dots\dots a_n)}{K(a_2 \dots\dots\dots a_n)}$$

Consider now the current in the element x_3; current entering the network will divide between x_2 and x_3, the fraction of the current entering x_3 will be given by

$$\frac{\text{Admittance of network commencing at } x_3}{\text{Admittance of } x_2 + \text{Admittance of network commencing at } x_3}$$

$$= \frac{\dfrac{K(a_4 \dots\dots\dots a_n)}{K(a_3 \dots\dots\dots a_n)}}{a_2 + \dfrac{K(a_4 \dots\dots\dots a_n)}{K(a_3 \dots\dots\dots a_n)}}$$

$$= \frac{K(a_4 \dots\dots\dots a_n)}{a_2 K(a_3 \dots\dots\dots a_n) + K(a_4 \dots\dots\dots a_n)}$$

$$= \frac{K(a_4 \dots\dots\dots a_n)}{K(a_2 \dots\dots\dots a_n)}$$

Similarly of this current a fraction

$$\frac{K(a_6 \dots\dots\dots a_n)}{K(a_4 \dots\dots\dots a_n)}$$

will enter x_5.

So that the fraction of the original current passing through x_5 will be

$$\frac{K(a_4 \dots\dots\dots a_n)}{K(a_2 \dots\dots\dots a_n)} \times \frac{K(a_6 \dots\dots\dots a_n)}{K(a_4 \dots\dots\dots a_n)}$$

$$= \frac{K(a_6, \dots\dots\dots a_n)}{K(a_2, \dots\dots\dots a_n)}$$

The process can be continued and the general result is that the current through any series member x_{2r+1} is equal to the input current multiplied by

$$\frac{K\,(a_{2r+2},\dots\dots\dots a_n)}{K\,(a_2\dots\dots\dots a_n)}$$

and that the ratio of the current through x_{2r+1} to the current through x_{2s+1}

$$= \frac{K\,(a_{2r+2},\dots\dots\dots a_n)}{K\,(a_{2s+2}\dots\dots\dots a_n)}$$

Let the current in the series member x_{2r+1} due to a voltage v impressed at the sending end AB be v/Z_{2r+1} so that Z_{2r+1} can be termed the impedance of x_{2r+1} with respect to the terminals AB; Z_{2r+1} can now be determined; the current through x_{2r+1} is $K\,(a_{2r+2}\dots\dots\dots a_n)/K\,(a_2\dots\dots\dots a_n)$ times the current through x_1 and the current through x_1 is

$$v \Big/ \frac{K\,(a_1\dots\dots\dots a_n)}{K\,(a_2\dots\dots\dots a_n)}$$

and therefore the current through x_{2r+1} is equal to

$$v \Big/ \frac{K\,(a_1\dots\dots\dots a_n)}{K\,(a_{2r+2}\dots\dots\dots a_n)}$$

$$\text{whence } Z_{2r+1} = \frac{K\,(a_1\dots\dots\dots a_n)}{K\,(a_{2r+2}\dots\dots\dots a_n)}$$

Next consider the voltages across shunt members; it a voltage is applied at AB the fraction of the voltage across x_2 will be given by

$$\frac{\text{Impedance of network commencing at } x_2}{\text{Impedance of network commencing at } x_1}$$

$$= \frac{K\,(a_3\dots\dots\dots a_n)}{K\,(a_2\dots\dots\dots a_n)} \Big/ \frac{K\,(a_1\dots\dots\dots a_n)}{K\,(a_2\dots\dots\dots a_n)}$$

$$= \frac{K\,(a_3\dots\dots\dots a_n)}{K\,(a_1\dots\dots\dots a_n)}$$

Of this voltage across x_2 which is the input voltage to the network beginning at x_3 a fraction $K\,(a_5\dots\dots\dots a_n)/K\,(a_3\dots\dots\dots a_n)$ will be the across voltage of x_4.

So that, of the original applied voltage, a fraction

$$\frac{K\,(a_5\dots\dots\dots a_n)}{K\,(a_1\dots\dots\dots a_n)}$$

will be the voltage across x_4. Continuing in the same way, the voltage across the shunt element x_{2r} is equal to the input voltage multiplied by

$$\frac{K\,(a_{2r+1}\dots\dots\dots a_n)}{K\,(a_1\dots\dots\dots a_n)}$$

and the ratio of the voltage across x_{2r} to the voltage across x_{2s} is

$$\frac{K\,(a_{2r+1}\ldots\ldots\ldots a_n)}{K\,(a_{2s+1}\ldots\ldots\ldots a_n)}$$

If Z_{2r} is the impedance of the shunt element x_{2r} with respect to the terminals AB it follows that—

$$Z_{2r}=\frac{1}{a_{2r}}\quad\frac{K\,(a_1\ldots\ldots\ldots a_n)}{K\,(a_{2r+1}\ldots\ldots\ldots a_n)}$$

The receiving and impedance can be obtained from either the series or shunt formula (since the currents through x_{n-1} and x_n are equal) and is equal to

$$\frac{K\,(a_1\ldots\ldots\ldots a_n)}{a_n}$$

It has been taken throughout that the network commences with a series member; there is no loss of generality in this, for if the network commences with a shunt member it is merely necessary to put $a_1=0$ and notice that

$$K\,(0,\ a_2,\ a_3\ldots\ldots\ldots a_n)=K\,(a_3\ldots\ldots\ldots a_n)$$

A.C.B.

NOTES & COMMENTS

NOTES AND COMMENTS.

We are publishing in this issue an exhaustive summary of Colonel Purves's Institution paper on "The Post Office and Automatic Telephony," and the discussion that followed. Although rather belated—we tried to help a large number of our readers who are not supplied with the Proceedings of the Institution direct by sending them complete copies free of expense—the paper loses nothing of its value by the delay, and we are of opinion that a better appreciation of its contents will be obtained in this wise than if it had been spread in full over three or four issues of the Journal. The purely historical portion has been omitted, as our pages have contained sufficient information on this part of the subject during the past dozen years.

In our last issue we published an important article by Messrs. Jenkins and Paterson on the methods to be employed in dialling-in and -out between automatic and manual exchanges. Unfortunately quite a number of errors crept into the paper, and in order to remedy them we are sending out in this number a separate slip containing the modifications to be made to bring the article into line with the actual conditions. We are sorry for these mistakes, which were due to various circumstances not altogether under our control, and we hope the corrections now issued will enable those interested to bring the letterpress and diagrams into line.

Wheatstone Commemoration.—To mark the fiftieth anniversary of the death of Sir Charles Wheatstone, the celebrated inventor and Professor of Natural Philosophy at King's College, London, a tablet to his memory was unveiled in Gloucester Cathedral on 19th October last.

At South Kensington, the Science Museum authorities arranged a special two weeks exhibition of Sir Charles Wheatstone's numerous inventions. The telegraph side was well represented, the well-known five-needle telegraph instrument, with its twelve sending keys, being a prominent object. There was also a double needle telegraph framed in an elaborately carved Gothic case. This instrument was used in the Houses of Parliament in 1846 and the case was designed in imitation of the architectural style of the building in which it was installed. Perhaps the most interesting electrical exhibits were the specimens of early Wheatstone automatic apparatus. The original transmitters were worked by hand, the slip being passed through the transmitter by the action of mechanism kept in motion by the operator turning a handle. A.B.C. communicators and indicators, a quaint whistling telegraph and numerous other instruments went to make up what was, perhaps, one of the most complete displays of Sir Charles's work that has ever been assembled. Among the non-electrical exhibits were a spectroscope, concertinas and many other objects which illustrated the versatility of his genius.

Altogether the exhibition was of great historical interest and was visited by many notable personages, including two of Sir Charles Wheatstone's daughters, who took the opportunity of again inspecting, after a lapse of many years, some of their father's memorable achievements.

An interesting example of the value of the Journal to Colonial Administrations has just come to hand from Lagos, Nigeria. In the July issue we published illustrations and a description of a new type of Utility Service Motor Vehicle being tried in the home service. The description has been read with great interest (says the Acting-Engineer-in-Chief of Nigeria) as they are considering the employment of motors on the lines in the "bush." He has asked for a copy of the drawings of the bodywork to be sent, so that they may benefit by the home experience.

The Relay Automatic Telephone Company has received a contract for a new 300-line automatic exchange for Fontainebleau, which will be of the same type as that supplied to the British G.P.O. The job will be engineered from Relay House.

We have received from the N.V. Electriciteits-Maatschappij Zeva, of Admiral de Ruyterweg 398, Amsterdam, a specimen of their "Zeva" electric soldering iron for telephone and telegraph purposes. The heating element is cast under high pressure in a mass of aluminium and lies solidly locked up in the metal, being thus protected from shocks and jars and free from the effects of acid, dust and water. The bit is adjustable, being held by a lock screw which passes through the wall of the aluminium sheath. The apparatus looks a very serviceable tool; it is fitted with a stout flexible cord terminating on a 2-way plug for attachment to a wall plug and is suitable for a 220-volt circuit.

The new Tungstone Accumulator Co., Ltd., of 3, St. Bride's House, Salisbury Square, E.C.4, has sent us a copy of their pamphlet giving details of the methods employed in the construction of their Tungstone cells. The features of the type are the method of using the antimony stiffening in the plate grids and the pasting of the plates entirely by high pressure die casting machinery. It is claimed that the robust plates permit charge and discharge with safety at continuous high rates. We should recommend that the volume or weight of either pure or 1240 Sp. G. acid required for filling up any particular size of battery should be quoted, and also that a filler which does not fit the feed hole exactly should be supplied. Some difficulty was experienced on both these points in filling up a battery which the Company has kindly sent us for trial.

THE THEORY OF THE SHUNTED CONDENSER.

The Managing Editor.

Sir,—Mr. Morice's communication in your last issue on the subject of what precisely happens when $L = CR^2$, contains the following paragraph on which I should like to comment:—

"If $L = CR^2$ and also (*a*) is of the oscillatory form, then it follows that the *quantity* of electricity passing through the relay on suddenly discharging the circuit is zero. If a truly ballistic galvanometer were placed in the circuit in the position shown dotted in Fig. 1 it would not be affected. This then is the significance of the relation $L = CR^2$."

I quite agree that an interesting property of the shunted condenser circuit when $L = CR^2$ is here brought to light, and I am glad to see it placed on record.

I will confine my comments to the bearing that rapid signalling has on the property in question. It is evident that the total quantity of electricity which would pass through the supposed ballistic galvanometer would only amount to zero if the current were allowed to flow long enough for the summation to zero to take place. This is not necessarily the case. Curve A in Mr. Morice's letter admirably illustrates my point. A rapid dot signal would be completed in less than half the time shown in this curve. Let us examine this case. The time required for the sum of the + and − quantities of electricity shown in the curve to amount to zero cannot be taken, even approximately, as less than 0.02 sec. Now we learn from Mr. Morice's article (page 15 of the April number of the Journal) that for a speed of 400 words per minute, a " dot " is completed in 0.0031 second. This is, however, a very high speed, and I will suppose that half the speed named is taken, and that a dot lasts for 0.0062 second. A reference to the curve in question will show that the transient current is very far from being completed at the end of 0.0062 second, and in practice the transient signal would be cut off with the dot and not completed although the dot would be fully registered. This is very far from being an isolated example.

So far as rapid signalling is concerned, there are one or two properties which are manifested when $L = CR^2$ which appear to me to be specially important. I showed in a general way in my previous letter that a relatively rapid rise of signals is then obtained, and I desire to take advantage of this opportunity to give precise formulæ which permit of the easy calculation of the rate of rise of the signals and other important data. All the formulæ assume that $L = CR^2$.

As shown in my former letter, the instantaneous transient current may be calculated from the equation

$$I = \frac{V}{R+R_1}\left[1 - e^{-at}(\cos\beta t - \frac{a}{\beta}\sin\beta t)\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

R being the resistance in the shunted condenser circuit and R_1 being the resistance of the relay.

It follows that at some instant t_1 we may have a value such that

$$\cos\beta t_1 = \frac{a}{\beta}\sin\beta t_1 \text{ or}$$

$$\frac{a}{\beta} = \cot\beta t_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

When this condition obtains the quantity in the inner brackets in (1) is zero and (1) becomes $I = \frac{E}{R+R_1}$

It is then evident that at the time t_1 the current has temporarily risen to its normal value $\frac{E}{R+R_1}$. If we know the value of $\frac{a}{\beta}$ we can find the value of βt_1 from (2), and suitable trigonomertical tables.

It can be shown that $\frac{a}{\beta}$ may be expressed in terms of the resistances R and R_1 as follows:

$$\frac{\alpha}{\beta}=\sqrt{\frac{R+R_1}{3R-R_1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

R_1 is a known constant and therefore (3) may be solved for any value of R which we may place in the rheostat—this value of R must be known.

The values of α and β may also readily be found. It was shown in my former letter that α may be written

$$\alpha=\frac{R+R_1}{2L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

and from (3) and (4)

$$\beta=\frac{\alpha}{\sqrt{\frac{R+R_1}{3R-R_1}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Also since $L = CR^2$

$$C=\frac{L}{R^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Having found βt_1 as described, t_1 may evidently be written

$$t_1=\frac{\beta t_1}{\beta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Some interesting conclusions may be deduced by the aid of these simple formulæ, and to show them more clearly I have constructed the following table:—

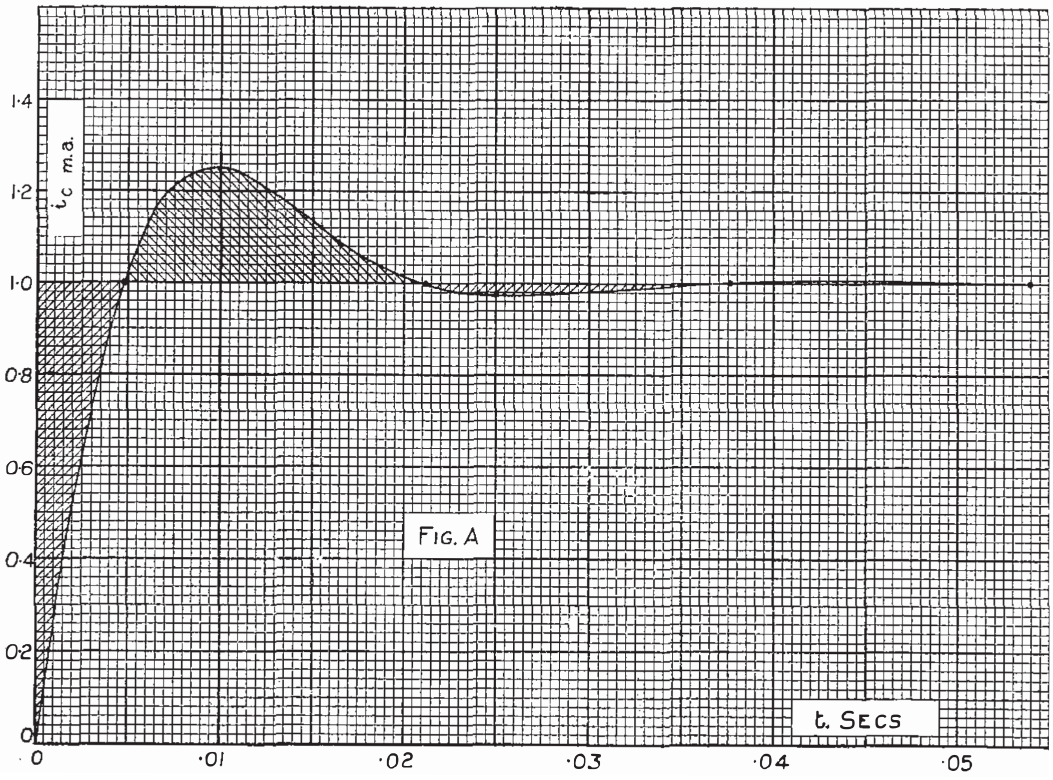
$L=CR^2$ $L=3{\cdot}5$ henry $R_1=300$ ohms†

R ohms.	$C\mu f$	α	β	$\frac{\alpha}{\beta}$	t_1 secs.	Maximum Reversed transient Current in terms of normal Current*
500	14	114	140	0.82	0.0063	0.018
700	7·14	143	191	0.75	0.0049	0.024
1000	3·5	186	270	0.69	0.0036	0.030
1500	1.55	257	393	0.65	0.0025	0.035
2000	0.875	329	518	0.64	0.0019	0.038
2500	0.56	400	641	0.62	0.0016	0.040
						* Normal Current = 1

† In these conditions formula (1) holds good for all values of C up to 350 microfarads.

It is evident from this table that as the resistance is increased and the capacity suitably adjusted in accordance with the CR^2 rule the current rises more and more rapidly to its normal value, at the time t_1 after establishing the circuit. From an extended table of this kind—or a curve—t_1 could readily be found appropriate to the speed of any "dot" signal. Any arbitrary manipulation of C and R would not be likely to produce such an exact result. According to our table, however, an increased rate of rise of the current has to be paid for by an increase of resistance and its consequences.

After the current has temporarily risen to the value t_1 it continues to rise, and it has a value exceeding the normal during the time that the angle βt executes a further half revolution. Mr. Morice's curve A, in his letter, affords a clear example of the characteristics of the curve and I here reproduce it, by permission, to facilitate my explanation.



CURVE A.

(*a*) The current rises *steeply* to its normal value 1.0 in the time I have called t_1, and the column headed t_1 in the table shows the variations of the time required for the current to attain the normal value.

(*b*) The current rises above its normal value for half a revolution. The maximum amplitude is attained at time $2t_1$ and it increases with the resistance R and is *large*. The excess current (that above normal) assists the signals in all cases.

It may be, and often is the case that dots are too rapid to benefit from the augmented current. Still, so long as the transient current exists it will either be in a direction which would assist or retard signals, and the dash benefits to some extent from this limited advantage.

(*c*) After the transient current is reversed (and in the case of Curve (A) descends below the value of 1.0) the resulting transient current is very small, and this *small* value, though not constant, is a characteristic feature of the curves when $L = CR^2$. The estimated maximum values of the reversed current are shown in the last column of the preceding table, and it will be observed that in all cases the values are small. They occur at a time t_2 such that $t_2 = 2t_1 + \frac{\pi}{\beta}$

The characteristics underlined in (*a*), (*b*) and (*c*) are favourable ones and are automatically obtained when $L = CR^2$ in the range of values taken.

I showed in a general way in my former communication that the relation $L = CR^2$ ensures comparatively rapid signals as compared with some other combinations; but space does not permit of extending the comparison.

It is quite true that this study assumes a fixed value of the circuit constants for any particular case; but the amount of probable concordance between calculation and experiment was well shown in Mr. Morice's original article. In any case, theory clearly proves that the rate of rise of telegraph signals can be increased by the device of the Shunted Condenser, and an important step in the full and scientific solution of the problem is to determine and understand the factors entering into it. I have endeavoured to assist in this direction.

Yours faithfully,

J. G. HILL.

CORRESPONDENCE.

To the Editor of *The Post Office Electrical Engineers' Journal.*

Dear Sir,

Some time ago A. H. Roberts published an interesting series of articles in your Journal on the history of the electrical telegraph.[*] These articles contained, however, some statements about the discovery of electromagnetism, which can hardly be said to be altogether correct.[†] The statements I have in mind are the following:—

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[*] The Romance and History of the Electric Telegraph. Vol. 16, p. 121, 207 and 401. Vol. 17, p. 1, 91 and 171.

[†] The attention of "Danmarks Naturvidenskabelige Samfund" (a Danish society for the promotion of co-operation between science and industry) was drawn to these articles by a letter from "Society of Danish Civil Engineers in Great Britain and Ireland."

"In 1802, Romagnosi, an Italian, casually announced his discovery that the magnetic needle was deflected by a galvanic current and mention is made of the fact by Aldini in his book, Essai theorique et experimental sur le Galvanisme, published in 1804, but Professor Oersted, of Copenhagen, is credited with the honour of having been the first to investigate and describe the relationship existing between magnetism and electricity."*

We Danish scientists believe that the priority for the discovery of electromagnetism belongs entirely and solely to the Dane, H. C. Oersted, and I think that by far the greatest part of all scientists agree in this view.

As, however, the name of Romagnosi now and then is mentioned in connection with this discovery it was thought worth while to investigate the question thoroughly. The original publications bearing on this subject have been collected by M. C. Harding, secretary to "Danmarks Naturvidenskabelige Samfund," and abstracts of these publications in the original language have been given in the enclosed paper by Professor K. Prytz under the headings: *Original texts*; besides, the paper contains an English translation of these abstracts and a commentary on the works of Romagnosi. This Commentary has been made by Professor K. Prytz, who has also supervised the English translation.

After this documentation I think it is perfectly clear that *the work of Romagnosi has nothing whatever to do with the discovery of electromagnetism.*

I have been asked to transmit Professor Prytz's paper to you and to beg you to be kind enough to publish it in your esteemed Journal, at least Professor K. Prytz's commentary and the English translation of the documents, but we should very much prefer also to have the original texts published, as the translation of these old memoires into modern language is somewhat difficult.

For further information about *H. C. Oersted,* his work and life, I am sending you, by separate mail, some books published in connection with the centenary of his discovery of electromagnetism. These books are:—*Kirstine Meyer*: "Scientific Life and Works of H. C. Oersted."

M. C. Harding: "Correspondence de H. C. Oersted avec divers savants."

Absalon Larsen: "The Discovery of Electromagnetism made in the year 1820 by H. C. Oersted."

I am, dear Sir,
Yours very truly,
P. O. PEDERSEN,
Professor, The Royal Technical College, Copenhagen.

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* Vol. 16, p. 222.

CORRESPONDENCE.

HANS CHRISTIAN OERSTED'S DISCOVERY OF ELECTROMAGNETISM.

By Professor K. Prytz.

The Italian Romagnosi's experiments with the voltaic pile in combination with a compass needle have been cited against Hans Christian Oersted's priority for the discovery of electromagnetism. These experiments have been mentioned (1) in "Opere di G. D. Romagnosi riordinate ed illustrate de Alessandro de Georgi," volume I., Milan, 1841; (2) in Izarn, "Manuel du Galvanisme," Paris, 1804; (3) in Aldini. "Essai théorique et expérimental sur le Galvanisme," volume I., Paris, 1804. In the following will be set forth, using the technical expressions of the present day, what may be assumed to have really happened during the above mentioned experiments. In addition, the information concerning the experiments contained in the said works will be re-printed below and reproduced, besides, in English translation.

(1) The experiments mentioned in this report may be recapitulated as follows: Romagnosi placed a compass needle disposed in an open wooden box in the vicinity of a Volta's pile. In order to insulate the needle he placed the box on a glass insulator. One terminal of the Volta's pile was connected to a conductor, the latter being passed through a glass tube, in order that when handled by means of the glass tube the conductor might be moved about in an insulated state. The other terminal of the Volta's pile is not mentioned.

Romagnosi touched the magnetic needle with the end of the conductor, whereby the needle deviated from its position of equilibrium, and remained in its new position, after the conductor had been removed, from which fact he concluded that the needle had lost its magnetism.

Then he lifted the box carefully, with the result that the magnetic needle, while making small oscillations, *i.e.,* not suddenly, returned into its position of equilibrium during the course of a few seconds. Romagnosi concluded from this that the presumably de-magnetised needle hereby recovered its magnetism.

It is evident from the report that during this experiment no closure of current was affected, and therefore any connection between this experiment and electromagnetism is precluded. The phenomena of the experiment may presumably be explained as electrostatic action in connection with frictional resistance from the pin supporting the compass needle. Romagnosi's explanation that the magnetism of the compass needle disappeared by simple contact with an electric conductor, and that the magnetism reappeared, because he held the box containing the needle in his hand, may hardly be accepted at present.

(2) Izarn describes another experiment, which presumably must be due to Romagnosi, in the following manner: Between the electrodes in an apparatus arranged like a Henley's discharging apparatus a magnetic needle was placed, either fixed in small pincers (petite pince) or resting on flattened extensions (petit ajoutage applati) on the free ends of the electrodes, whereafter the current from a Volta's pile was passed through the needle. Hereby a declination (déclinaison) of the needle was caused. As owing to its manner of attachment the needle could not alter its position, while the current was passing through it, the deviation here concerned must have appeared afterwards, after the needle had again been freed. For some obscure reason the position of the magnetic axis of the needle had been altered slightly. Possibly the heat generated by the current in connection with terrestrial magnetism may have been the cause.

The result of this experiment cannot possibly be considered a discovery of electromagnetism, as an electromagnet action cannot lead to a result like the one described by Izarn.

(3) Aldini makes in his report merely the statement that Romagnosi, called by him erroneously Romanési, has proved that " galvanism causes the magnetic needle to deviate." There is hardly any doubt but that he refers to the experiment mentioned under (1). One would in fact have to be very modest as to the requirements for defining a discovery, if one were to consider the discovery of electromagnetism to be involved in an isolated statement of this nature.

[*Although Professor Prytz's translations of the original texts are extremely interesting we have not the space available for reproducing them, especially since Mr. Roberts in his letter below says that the trend of his remarks has been misapprehended by our Danish friends.*—EDS., *P.O.E.E. Journal.*]

To the Editor of *The Post Office Electrical Engineers' Journal.*

Sir,

From Professor Pedersen's letter of 8th September last, I regret to find that the intention of the short summary of " Oersted's investigations," contained in Part II. of " The Romance and History of the Electric Telegraph," has been misapprehended. So far from attributing the discovery of electromagnetism to Romagnosi, the whole trend of the article acknowledges that Oersted made that great discovery, but that Romagnosi was the first to record an experiment in which a magnetic needle was deflected by the aid of a voltaic pile.

It is quite natural that in those days, before electrical units were so well defined as they now are, the terms " electric current " and " galvanic fluid " should have been used to describe the cause of observed effects which to-day would be attributed to other means. It was evidently so in Romagnosi's case.

In the paragraph quoted by Professor Pedersen, the last statement " But Professor Oersted, of Copenhagen, is credited with the honour of having been the first to investigate and describe the relationship existing between magnetism and electricity," obviously means that Professor Oersted was rightly credited with the honour, otherwise the succeeding paragraphs would be contradictory.

It has been stated by some writers that Romagnosi would have obtained a similar result if his balanced needle had been constructed of non-magnetic metal and that this being so, nothing new was disclosed by the experiment which therefore was of no importance. To discuss the matter in this strain is to ignore the central fact that Romagnosi was historically the first to use a magnetic needle and voltaic pile *in combination*.

Is it not probable that the publication of Romagnosi's experiment influenced other minds to try the same combination in a different way?

So far as I can ascertain, although he lived for many years after the publication of Professor Oersted's booklet on electromagnetism, Romagnosi never disputed Oersted's claim to that epoch-making discovery.

Oersted's reputation as a brilliant leader in several branches of science, including electricity, rests on too secure a foundation to be shaken, but, while remembering this, let us not forget the work performed by his less illustrious predecessors and contemporaries.

Yours faithfully,

A. H. ROBERTS.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Chapeltown	Auto	850
Headingly	,,	1220
Newport	,,	600
Paignton	,,	700

Exchange.	Type.	No. of Lines.
Roundhay	Auto	800
Stanningley	,,	680
Stockport Extension ...	,,	1200
Torquay	,,	1800
Birmingham Central Extension	Manual	1250
Caterham Valley	,,	520
Chiswick Extension ...	,,	1500
Coatbridge	,,	600
Cradley Heath	,,	400
Didsbury	,,	1660
East Ham	,,	1700
Guildford Extension ...	,,	540
Knock	,,	940
Leigh (Lancs.)	,,	680
Northam	,,	300
Porth	,,	240
Ramsgate Extension ...	,,	380
Ravensbourne Extension ...	,,	1200
St. Annes Extension ...	,,	540
Truro Extension	,,	100
Whitstable	,,	300
Worthing Extension ...	,,	660
Amalgamated Dental Co....	P.A.B.X.	50
Appleyards, Ltd.	,,	30
Bensons, Ltd.	,,	70
Balfour, Ltd.	,,	80
Birmingham Maternity Hospital	,,	20
Chad Valley Co.	,,	30
Co-Op. Wholesale ...	,,	160
Coutts & Co.	,,	50
Crosse & Blackwell ...	,,	180
Daily Express	,,	120
Delaney's	,,	30
Kendrick Jefferson ...	,,	40
Lines, Ltd.	,,	50
McNamara	,,	80
Morris Motors	,,	130
Port of London Authority (4)	,,	470
Scottish Oils	,,	60
Shanks, Ltd.	,,	40
Simons, Ltd.	,,	30
Union Cold Storage ...	,,	230
Waddington, Ltd.	,,	30

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Arkwright	Auto	1000
Sherwood	,,	1190
Wilpshire	,,	270
Dumfries	Manual	700
Popesgrove	,,	1360
Primrose Hill	,,	4500
Seven Kings	,,	1370
Wellington (Salop) ...	,,	480
Bilsland Bros.	P.A.B.X.	40
Birkenhead Corporation...	,,	100

Exchange.	Type.	No. of Lines.
Bleachers' Association ...	,,	100
British B.C. Co.	,,	30
Burndepts	,,	10
Carpet Trades	,,	50
Coopers, Ltd.	,,	20
Hall & Sons	,,	30
Harrisons	,,	30
Jarrett Rainsford	,,	40
Lancaster C.C.	,,	30
Liverpool Courier	,,	20
Mannesmann Tubes ...	,,	40
Manchester Corporation...	,,	30
Observer	,,	30
Pearson Dorman Long ...	,,	50
Sharp & Sons	,,	30
Simons, Ltd.	,,	30
Shell Mex	,,	30
Taylor's Drug Co. ...	,,	40
Treloar's Hospital ...	,,	30
Vulcan Foundry	,,	40
Zwanenbergs, Ltd. ...	,,	20

Orders have been placed for Extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
Blackburn	Auto	1000
York	,,	380
Royal (London)	Manual	2280

Extension Working in Automatic Exchange Areas.

In connection with subscribers' installations in automatic exchange areas, a new bell-set (No. 20) has been designed for use at the main station, where extension working in accordance with Plans Nos. 5, 5A, 7 and 7A is provided.

The bell-set in these cases includes in addition to the bell, a switch and indicator for controlling the connections to the extensions and with the switch in the "through" position (*i.e.*, exchange to extension) it is necessary for the bell to be in circuit to enable the extension to call the main station even though secrecy against the main is provided in the "through" position of the switch.

The essential feature of the new bell-set is the provision of a combined relay and indicator in place of the indicator provided in the former bell-set (No. 13) which makes it possible to avoid the tinkling of the switch bell at the main station when the dial is operated at the extension station. This is accomplished by arranging with the switch in the " through " position for the combined relay and indicator to be controlled by the loop of the extension telephone and, when operated, to disconnect the switch bell from the line.

In addition to overcoming the tinkling trouble referred to above, the new bell-set gives considerably less impulse distortion whilst dialling from the extension station and a slight improvement in transmission as compared with the old type of bell-set.

MR. A. H. ROBERTS.

Mr. A. H. Roberts retired from the service on the 31st March last. He was appointed S.C. and T. at Exeter in 1884 and in 1898 was made Relay Clerk at Lowestoft. In 1901 Mr. Roberts was sent to Emden for two months to study German repeater working, and in 1902 he was appointed Second Class Engineer at Birmingham; he was promoted to be Estimates Engineer there in 1909. Mr. Roberts was transferred two years later to the Telegraph Section, Engineer-in-Chief's Office. During the war he was sent to Northern Russia and spent eight months under very trying conditions. In conjunction with Russian engineers he supervised the equipment of cable telegraph offices at Murmansk, Yukanskie and Archangel, for which he received the thanks of the Minister of Posts and Telegraphs under the Kerensky Government. He was awarded the M.B.E. on his return.

" The Romance and History of the Electric Telegraph " is not the first of Mr. Roberts' excursions into the realm of literature; in 1896-7, in collaboration with Mr. S. E. J. Burrows, he wrote a series of articles on Technical Telegraphy for the *Telegraph Chronicle,* which was later published in book form and ran through three editions. On his retirement his colleagues presented him with a silver Queen Anne tea service, which he treasures as his most cherished possession. Since his retirement Mr. Roberts has been busy at the Science Museum, where his knowledge was very useful in arranging the elaborate telegraph exhibit now being installed there.

LONDON ENGINEERING DISTRICT NOTES.

Mileage Statistics.

During the three months ended 30th September, 1925, the following changes have occurred :—

Telegraphs.—Nett decrease in open wire of 18 miles and a nett increase in underground of 172 miles.

Telephone (Exchange).—Nett decrease in open wire (including aerial cable) of 846 miles and a nett increase in underground of 35,847 miles.

Telephone (Trunks).—Nett increases in open wire and underground of 1 mile and 2,112 miles respectively.

Pole Line.—Nett increase of 52 miles, bringing the total to date to 5,190 miles.

Pipe Line.—Nett increase of 178 miles, the total to date being 6,269 miles.

The total single wire mileages at the end of the period under review were :—

Telegraphs	24,184
Telephone (Exchange)	1,645,389
Telephone (Trunks)	57,666
Spares	48,654

External Construction.

During the quarter ended 25th September, 1925, 8,517 exchange lines, 5,798 internal extensions and 1,252 external extensions were provided. In the same period, 3,055 exchange lines, 2,815 internal extensions and 505 external extensions were recovered, making nett increases of 5,462 exchange lines, 2,983 internal extensions and 747 external extensions.

Internal Construction.

New Exchanges.—A new Manual Exchange (C.B.1, 1,700 lines) was opened at Grangewood (East Ham) on December 5th, and a new C.B. 10A Exchange (850 lines) was brought into use at Pinner on December 9th. The installation of new Manual Exchanges at Primrose Hill, Bexley Heath, Walworth, Battersea and Burgh Heath will be commenced shortly.

Substantial progress is being made with the construction of the Automatic Exchanges at Holborn and Bishopsgate. The installation of the Tandem Exchange in the Holborn Automatic Exchange building has been advanced materially.

Experimental Mechanical Tandem and C.C.I.—The installation work in connection with the trial of two mechanical tandem cordless " B " positions and one C.C.I. position in the City Exchange has been completed and tested out. It is anticipated that the positions will be brought into use in January.

Exchange Extensions.—Works of this nature affecting a very large number of Exchanges in the District continue to be heavy.

P.A.B.X.'s.—The demand for P.A.B.X.'s continues and the number of Exchanges of this type in the District is increasing steadily.

Trans-Atlantic Telephone Transmission.—The terminal apparatus has been delivered at G.P.O. South, and the work of installation is proceeding.

Telegraphs.

In connection with the considerable re-building operations at the C.T.O. a large new telegraph room, on the ground floor, has had to be equipped in space hitherto used for clerical work. This space, cleared of screens, provides accommodation for six quadruple-duplex Baudots, and several Morse sets. A complete system of line cables and power mains has been installed, together with a Divisional Test Box, a type apparently special to the C.T.O.

Four 2¼″ brass pneumatic tubes have been run; two to the

Central Hall, Ground Floor, and two to the Centre Third Floor, thus providing quick transit to any gallery in G.P.O. (West).

A new street-tube for the *Daily News* has been provided between C.T.O. and Bouverie Street. This makes the third tube provided for Press purposes to the C.T.O.

In connection with the re-construction of the C.T.O., the Engineering Department has been commended for the expedition and care with which the clearance of apparatus from more than half the great Centre and the diversion work in connection with the street and house tubes have been effected. The Centre is now a forest of timber supporting the fourth floor while the stanchions are being replaced, but the telegraph business appears to go forward with little disturbance.

A further advance has been made in connection with the abolition of the Intercommunication Switch. The Power Board has been dismantled and most of the new table-space has been fitted with direct circuits. An intermediate frame has also been made and fitted to accommodate the new ancillary system of switchboards.

Battery Work.—The District battery work, the large majority of which is carried out by the C.T.O. Section, has increased considerably and the accommodation at G.P.O. (West) has been inadequate for some time. A large workshop and a stores-room have now been provided at Cornwallis Road, adjacent to the Engineering fitters' shops, with a view to facilitate the work. Moulds have been obtained experimentally by means of which standard types of lugs can be prepared for combining the several types of plates into positive and negative sections, and for combining sections into complete cells. The present conditions are more favourable for dealing with the large amount of work continually on hand.

Threadneedle Street B.O.—The reconstruction at this office has permitted the transfer, from Stock Exchange premises to the first floor of the Post Office, of the Baudot and several Hughes instruments, which form together a miniature Foreign Gallery. This is distinct from the Provincial Gallery established on the second floor. A complete tube system has also been provided so that the telegraph room can receive carriers from the Stock Exchange within a few seconds and from the Central Telegraph Office in the course of a minute or two.

The conditions, both as regards light and accommodation, show a vast improvement on the old building. The mechanical clocks have been superseded by an electrical system, three loops being worked from one Master-clock.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

PROGRAMME OF CENTRE MEETINGS: SESSION 1925-6.

LONDON CENTRE.

1925.		
3 Oct.	"The Work of the Wireless Experimental Section"	Major A. G. Lee, M.C., B.SC., M.I.E.E.
4 Nov.	"The Problem of Flexibility on Cable Distribution" "Plant in Congested Areas"	Harvey Smith.
8 Dec.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.SC., M.I.E.E.
1926.		
2 Jan	"Precision Testing"	N. Layton.
9 Feb.	"Testing of Secondary Cells" "Torch Blowing Lamps"	Capt. N. F. Cave Browne Cave, B.SC., M.I.E.E.
9 Mar.	"The Testing of Telephone Circuits and Apparatus with Alternating Currents"	E. S. Ritter, B.SC., A.M.I.E.E. G. P. Milton.
1 May	"Automatic Trunking in Theory and Practice"	W. W. Gibson. G. F. O'Dell, B.SC., A.K.C., M.I.E.E.

NORTHERN CENTRE.

1925.		
1 Oct.	"The Law of Contract in relation to P.O. Engineering Contracts"	F. Johnston, A.C.I.S.
8 Nov.	"Balancing of Telephone Trunk Cables"	J. Lowe.
Dec.	Visit to Messrs. Hood Haggie's Rope Works at Willington Quay.	
1926.		
0 Jan.	"Telephone Repeaters"	C. Robinson, B.A., A.M.I.E.E. (*E.-in-C.O.*).
7 Feb.	"The Elements of Telephone Machine Switching"	F. W. Longmore.
7 Mar.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.SC., M.I.E.E. (*E.-in-C.O.*).
7 Apr.	"Final Selection for P.B.X."	J. H. Bell, A.M.I.E.E. (*E.-in-C.O.*).

NORTH EASTERN CENTRE.

1925.		
3 Oct.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.SC., M.I.E.E. (*E.-in-C.O.*).
0 Nov.	"Manufacture and Testing of Earthenware Conduit" (Lantern Lecture)	L. Tanner and J. C. Walker.
8 Dec.	"From Youth-in-Training to Engineer"	G. S. Wallace, A.M.I.E.E.
1926.		
2 Jan.	"Cable Faults, Causes and Remedies" (Lantern Lecture)	W. James.
9 Feb.	"Recruitment & Promotion of Staff"	W. H. Thorburn.
9 Mar.	"Slide Wire Bridge Testing"	A. C. Mayman.

NORTH WESTERN CENTRE.

1925.		
19 Oct.	"Accommodation"	A. W. Field, A.M.I.E.E.
30 Nov.	"Accidents on Duty"	R. A. Jones.
1926.		
18 Jan.	"Difficult Points in Cash Accounting" (Diary Pages and Time Sheets)	S. Storey.
	"Difficult Points in Stores Accounting"	A. J. Ross.

NORTH WESTERN CENTRE—*continued.*

Feb.	"Records of External Plant"... ...	H. S. Turner and H. F. Perry.
	"Amateur Wireless Stations"... ...	H. Horrocks.
Mar.	"Exchange Transfer Work under Functional Organisation" ... ... (Being an elaboration of the latter portion of the paper on the same subject read during the 1924-25 Session.)	S. Upton, A.M.I.E.E., & J. B. Glover, A.M.I.E.E.

SOUTH LANCS. CENTRE.

925.		
Oct.	"Progress and Development in the Engineering Department"	W. J. Medlyn, M.I.E.E.
Nov.	"A few Psychological and other Problems"	J. Cowie, M.I.E.E.
Nov.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	Capt. H. Hill, B.SC., M.I.E.E. (*E.-in-C.O.*).
926.		
Jan.	"Staff Matters. A General Review"...	G. H. Green.
Feb.	"Wireless"	E. H. Shaughnessy, O.B.E., M.I.E.E. (*E.-in-C.O.*).
Mar.	"Notes on Cabling Work and Labour Saving Tools"	R. C. Balcombe.

NORTH WALES CENTRE.

925.		
Oct.	"The Development of the Baudot System"	R. P. Collins.
Nov.	"Staff Proposals based on U.M.C. Statistics"	J. H. Whitehead.
Dec.	"The Work of the Engineering Testing Branch, Birmingham" ... (At Birmingham. With visit to Fordrough Lane Testing Branch and Factory).	Capt. N. F. Cave Browne Cave, B.SC., M.I.E.E.
1926.		
Jan.	"Relay System of Auto Switching—Private Branch Exchanges" ...	A. E. Stollard.
Feb.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	Capt. H. Hill, B.SC., M.I.E.E. (*E.-in-C.O.*).
Mar.	"Plant Records—Preparation & Use"	R. S. Dacombe and J. T. B. Donnellan.

SOUTH WALES CENTRE.

1925.		
Oct.	"Notes on Cabling Balancing" ...	J. F. Stewart.
Nov.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	Capt. H. Hill, B.SC., M.I.E.E. (*E.-in-C.O.*).
Dec.	"The Training of an Engineering Inspector"	H. W. Gifford.
1926.		
Jan.	"Some Points on Trunking in Automatic Exchanges"	G. F. O'Dell, B.SC., A.K.C., M.I.E.E. (*E.-in-C.O.*).
Feb.	"Inspection of Amateur Wireless Stations"	H. B. Somerville, B.ENG. (*E.-in-C.O.*).
Mar.	"Newport Repeater Station"... ...	S. H. Pendleton.

SOUTH WESTERN CENTRE.

1925.		
Oct.	Annual General Meeting and Chairman's Address	E. J. Eldridge, M.I.E.E.
Nov.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	Capt. H. Hill, B.SC., M.I.E.E. (*E.-in-C.O.*).
Dec.	"Automatic Telephony"	J. Emlyn Jones.
1926.		
Jan.	"Some Aspects of Automatic Trunking"	G. F. O'Dell, B.SC., A.K.C., M.I.E.E. (*E.-in-C.O.*).
Feb.	"Some Underground Contract Difficulties"	R. E. Soper.
Mar.	"Fault Localisation on Loaded Cables"	A. E. Hayward.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

NORTH MIDLAND CENTRE.

1925.		
12 Oct.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.Sc., M.I.E.E. (*E.-in-C.O.*).
16 Nov.	"Derby Repeater Station" (Paper to be read at Derby).	T. S. Skeet.
14 Dec.	"Common Estimating Mistakes" "Some Aspects of Automatic Telephones"	J. Wyatt. F. Coote.
1926.		
18 Jan.	"Contracts"	A. W. Blower.
22 Feb.	"Private Automatic Branch Exchanges" "The Relay Automatic System"	J. Hyde.
29 Mar.	"London-Derby Cable"	L. E. Watkins.

SOUTH MIDLAND CENTRE.

1925.		
28 Oct.	"Telephone Repeaters in Practice"	F. J. Gibbs.
25 Nov.	"Portsmouth and its Satellite Exchanges"	J. S. Brown, M.I.E.E.
9 Dec.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.Sc., M.I.E.E. (*E.-in-C.O.*).
1926.		
27 Jan.	"New Ways of doing old Jobs with a view to Time Saving"	V. Smith.
17 Feb.	"The training of Men for and Maintenance of Automatic Exchanges"	J. S. Brown, M.I.E.E.
31 Mar.	"Organisation in a Superintending Engineer's Office"	H. C. McCormack.
28 Apr.	"The Duties of an Inspector"	F. D. Traviss.

EASTERN CENTRE.

1925.		
27 Oct.	"Notes from London Automatic Lectures"	H. S. Noyes
15 Dec.	"Engineering Notes"	Major W. M. Batchelor, D.S.O., M.C.
1926.		
26 Jan.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.Sc., M.I.E.E. (*E.-in-C.O.*).
16 Feb.	"Coast Communications"	J. F. Lamb, M.I.E.E.
16 Mar.	"The Work of the Wireless Experimental Section"	Major A. G. Lee, M.C., B.Sc., M.I.E.E. (*E.-in-C.O.*).

SCOTLAND WEST CENTRE.

1925.		
4 Oct.	"Broadcasting"	J. M. Cameron (*British Broadcasting Co.*),
2 Nov.	"Wayleaves"	G. Taylor.
7 Dec.	"Main Cables—Loading, Testing and Transmission"	J. D. McLeod.
1926.		
1 Feb.	"Main Cable Records" "Local Cable Records"	M. McKenzie. T. Heggie.
1 Mar.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.Sc., M.I.E.E. (*E.-in-C.O.*)
	Films.	
5 Apr.	(1) "Travalogue of London and the Rural Districts with special reference to Telephone and Cable Development" (2) "Creating the Instruments of Speech"	*Western Electric Co. Films.*

SCOTLAND EAST CENTRE.

1925.		
17 Nov.	"Industrial Psychology"	E. J. Fraser.
15 Dec.	"Some features of Telegraph Engineering"	J. K. Murray, M.I.E.E.
1926.		
19 Jan.	"Automatic Trunking Schemes"	H. Dipple, A.M.I.E.E. (*E.-in-C.O.*).
16 Feb.	*To be arranged.*	J. W. Jarvis.
16 Mar.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.Sc., M.I.E.E. (*E.-in-C.O.*).
20 Apr.	"Edinburgh Automatic Telephone Exchange" (with visit to Exchange)	J. Innes.

NORTH IRELAND CENTRE.

1925.		
16 Nov.	"Plumbing and Jointing"	W. S. Keown.
2 Dec.	"The Engineering Aspect of Telephone Exchange Accommodation"	Capt. H. Hill, B.Sc., M.I.E.E. (*E.-in-C.O.*).
1926.		
11 Jan.	"Transposition and Revolving of Aerial Circuits"	A. E. Moore.
9 Feb.	"Main Cables, Loading, Testing and Transmission"	J. D. McLeod.
9 Mar	"Accidents on Duty"	J. Ardis. (Paper loaned by R. A. Jones, N. West Centre).

LOCAL CENTRE NOTES.

NORTHERN CENTRE.

The Session opened on the 21st October, 1925, when an admirable paper on "The Law of Contract in Relation to P.O. Engineering Contracts" was read by Mr. F. Johnston, A.C.I.S., before a well attended meeting.

On the 18th of November, Mr. J. Lowe read a paper on "The Balancing of Telephone Trunk Cables," which was well received by a large attendance of members. The Chairman extended a welcome to Mr. A. Morris, of the Engineer-in-Chief's Research Section, who delighted the meeting with a lucid and fluent description of the methods of balancing in vogue.

In connection with the discussions of the papers read before the Centre, the Committee has found it necessary to limit opening speakers to 10 minutes and subsequent speakers to 5 minutes in ordinary circumstances and at the discretion of the Chairman.

The Centre will visit Hood Haggie's Rope Works, at Willington Quay, on Wednesday afternoon, the 2nd of December.

The promotions of Messrs. Kitchen and Bellwood to the ranks of Assistant Staff Engineer and Executive Engineer respectively have given general satisfaction to the members, as both these gentlemen have taken a keen interest in the activities of the local Centre. Mr. Kitchen has served on the Local Committee and has also had the honour of representing his class on the Council. In addition, he has read several papers before the local Centre. Mr.

Bellwood has represented the Assistant Engineers' class on the Local Committee and has read no less than six papers before the Centre. One of his papers was printed by the Council.

SOUTH LANCS. CENTRE.

In accordance with the custom of the past few years the first meeting of the Session, held on the 19th October, was devoted to an address by the Chairman, Mr. W. J. Medlyn, on "Progress and Development in the Post Office Engineering Department." In this annual review of the previous year's work, the lecturer not only summarises the work accomplished by Post Office Engineers in such a manner as to require a minimum of effort on the part of the audience for its assimilation, but also draws many useful comparisons with other engineering works, and quotes largely from authoritative statements made by other Engineers of high standing, both in this and other counties. The address has a definite educational value and by focussing the attention of individual members on the work of the Post Office Engineering Department as a whole it enables each one better to appreciate his own relation to the larger design and is thus an incentive to carry out the work assigned to him in the most efficient manner possible. The large attendance and sustained attention throughout the address was an indication of the interest taken in the subject.

The second meeting of the Session was held on November 9th, when Mr. J. Cowie read a paper on "A few Psychological and other Problems." The novelty of the title undoubtedly stimulated the curiosity of the members, and there was a record attendance. At first sight the connection between the subject and practical engineering might appear to be somewhat remote, but the lecturer succeeded in showing that psychology in its application to administration, in the broadest sense, had a direct and important bearing upon engineering practice. Although made palatable by a characteristically humorous clothing the lecture gave much food for thought, and emphasised the importance of some knowledge of psychology, more especially by Engineers occupying administrative positions.

On November 30th, Captain H. Hill, of the Equipment Section of the Engineer-in-Chief's Office, visited this Centre, and read his instructive paper on "The Engineering Aspect of Telephone Exchange Accommodation." The pending introduction of automatic working into the Manchester Area has given rise to a large number of accommodation cases which are at present under consideration or contemplated, and a paper on the subject was, therefore, particularly opportune. The valuable information and data contained in the paper supplemented by other useful matter obtained as a result of the discussion will undoubtedly enable members of this Centre to facilitate the handling of such cases in future. There was a lengthy discussion in which numerous speakers participated, and it was obvious that the subject appealed very strongly to the audience.

The members of the Centre are indebted to Capt. Hill both for the excellent paper on a very live subject and also the full and lucid replies he gave to all the questions raised in the discussion.

SCOTLAND WEST CENTRE.

The opening lecture for the current Session took place on 5th October, when Mr. J. M. A. Cameron, Superintending Engineer for the Northern Area of the British Broadcasting Company, delivered a lecture on " Broadcasting." In the absence of Capt. Crompton, on leave, the Vice-Chairman of the Centre, Mr. Hardie, presided. A good attendance of members was augmented by visitors from kindred societies and from the District Manager's and Telegraph Staffs. The Chairman read a letter from Capt. Crompton expressing regret at his inability to be present and hoping for a pleasant meeting.

The lecturer outlined the system for broadcasting from Main Stations and dwelt at some length on the arrangements for modulation at the Station and Studio ends, and the methods of control of modulation. Relay stations were then described. As the lecturer had to catch a train for a Belfast connection within forty minutes of the conclusion of his lecture, discussion was necessarily curtailed.

The lecturer was accorded a very hearty vote of thanks.

Capt. Cooper, Contract Manager, thanked the local Centre Executive for the courtesy of the invitation, and expressed the hope that it would be repeated when suitable papers were being delivered.

The second meeting of the Centre was held on the 2nd November, Captain Crompton presiding over a good attendance of members.

The paper for the day was on the subject of " Wayleaves," contributed by Mr. G. Taylor, Higher Clerical Officer.

Mr. Taylor outlined the position of the Postmaster-General under the Telegraph Acts, 1863 to 1916, and thereafter dealt with the procedure to be followed by the Department's officers in dealing with wayleave consents affecting private property, and applications and notices in respect of the placing of telegraphs on public roads and streets. The general interest taken in the subject of the paper was manifested by the fact that over an hour was taken up by questions and discussion. Very interesting remarks were made by the Chairman and by Mr. Hardie, A.S.E.

On completion of the ordinary business, Mr. Hardie, in proposing a vote of thanks to the Chairman, mentioned that this would be the last occasion on which Capt. Crompton would be with us, owing to his approaching retirement. Mr. Hardie spoke in happy terms of our association with Capt. Crompton, and pointed to the increased membership of the local Centre, and to the improved attendance at meetings, as evidence of the good spirit inspired in the Centre under Capt. Crompton's Chairmanship. The vote of thanks was heartily responded to, and Capt. Crompton replied.

CAPTAIN CHARLES CROMPTON, O.B.E., R.E., M.I.E.E.

Captain Crompton was born on the 2nd November, 1864. He entered the Post Office Service at Liverpool as Telegraphist in April, 1885; was transferred to the Engineering Department at Liverpool, December, 1886; was promoted Engineer in Scotland West, June, 1894, and stationed at Oban.

Early in the following year the submarine cable connecting Oban with the islands of Mull, Coll and Tiree was broken and Captain Crompton established Wireless communication between Morvern on the Mainland and Craignure in Mull. The system used was that devised by the late Sir W. H. Preece, then Engineer-in-Chief of the Post Office, and a considerable number of public telegrams were satisfactorily dealt with during a period of ten days until the cable ship arrived and restored normal conditions by repairing the submarine cable. It should be noted that the foregoing constituted the first occasion on which Wireless Telegraphy was used commercially in Great Britain, if not in the world. Senator Marconi arrived in London later the same year and, with the assistance of the British Post Office, conducted experiments which resulted in the Wireless system as known to-day in all parts of the world.

In 1896 Capt. Crompton was transferred to Warrington in connection with the transfer of the Trunk Telephone lines from the late National Telephone Co. to the Post Office.

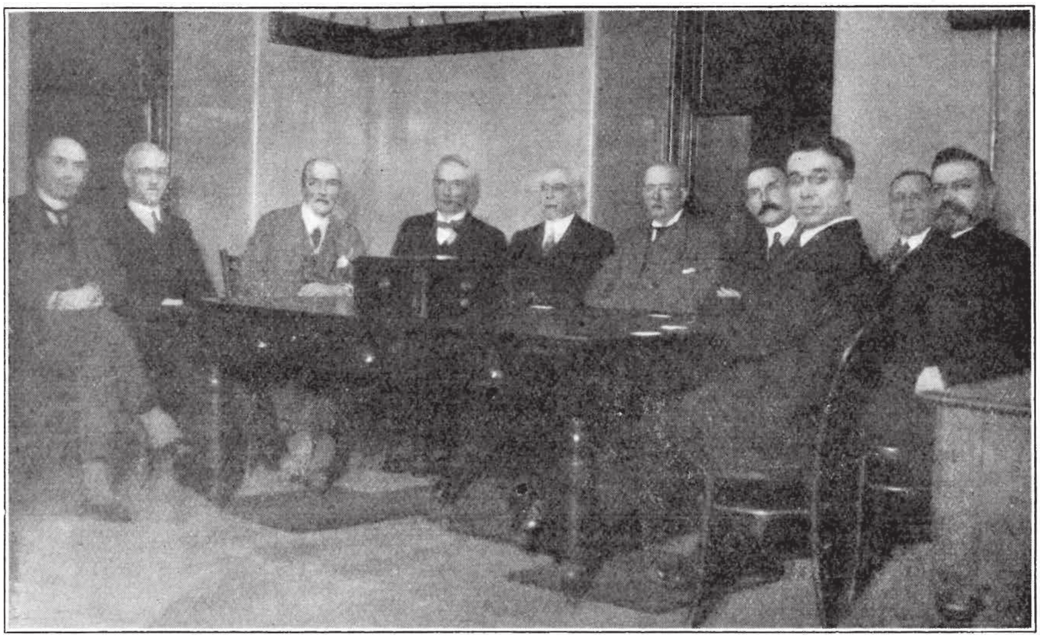
During the latter part of the South African War, viz., from March, 1900, to November, 1901, Capt. Crompton was loaned to the Royal Engineers (Telegraph Battalion) Southern District, and acted as Superintending Engineer of a Sub-division with Headquarters at Basingstoke.

After this Capt. Crompton was given charge of a section of underground cabling of London for the then extensive Post Office scheme of telephoning the Metropolis.

In 1904 Capt. Crompton went as Executive Engineer to Bradford in charge of the Section, but two years later was recalled to London as an Assistant Staff Officer in the Engineer-in-Chief's Office.

In 1908 Capt. Crompton went to Edinburgh as Assistant Superintending Engineer.

When the late War broke out he was appointed adviser on Telegraph and Telephone communications in all Scotland to the General Officer Commanding, Scottish Command, and, later, to the Commander-in-Chief, Coast of Scotland, Rosyth, with the rank of Captain and dealt with the communications of the premier Services as well as many others which sprang up; R.A.F. Anti-Aircraft, Ministry of Munitions, etc., etc., until some time after the end of the war. He was awarded the O.B.E. in 1921 for his services.



From left to right: W. E. Gauntlett, District Manager, Scot. W.; R. Aitken, Superintending Engineer, Scot. W.; Capt. Crompton; J. D. Taylor, S.E., Scot. E.; S. G. Forsythe, C.B.E., Postmaster, Glasgow; R. Cunningham, Sectional Engineer; D. Dunlop, Surveyor, Scot. W.; W. E. Coombs, District Manager, Glasgow; A. B. Gilbert, A.S.E., Scot. E.; J. Hardie, A.S.E., Scot. W.

In August, 1921, Capt. Crompton was promoted to be Superintending Engineer in charge of the South Wales Engineering District.

In 1924 he was transferred to the charge of the Scotland (West) Engineering District with Headquarters at Glasgow.

Having completed 40 years' service he retired under the age limit on November 30th, thus ending his Engineering career as head of the same District in which he started as a junior engineer 31 years ago.

At a meeting of the Engineering Staff, under the Chairmanship of Mr. R. Cunningham, Executive Engineer, at the Head Post Office, Glasgow, on Monday, 30th November, he was presented with a handsome canteen of cutlery from his colleagues in the Service. The presentation was made by Mr. John Hardie, A.S.E., and among those present were Messrs. S. G. Forsythe, C.B.E., Postmaster-Surveyor, Glasgow; D. Dunlop, Surveyor, Scot. W.; J. D. Taylor, S.E. Edinburgh, and members of the various departments with which Captain Crompton had dealings. The speakers were representative of all grades and all spoke in appreciatory terms of their relationship with Capt. Crompton. The accompanying photo is the best that could be obtained of a memorable gathering.

EASTERN CENTRE.

A four-valve wireless set has just been installed at the Chelmsford Hospital by voluntary effort on the part of the Chelmsford Post Office engineering and general staffs, who, with the hearty co-operation of the Postmaster (Mr. W. Hawkins) and others, collected the necessary money. Other assistance was willingly rendered.

The scheme was brought into being by Mr. O. D. Robinson, the senior engineering inspector of the Chelmsford area Post Office engineers. Mr. Hawkins acted as treasurer, and postmen in particular did splendid service in collecting. The construction of the set was done by Mr. L. G. Hazell, of the Marconi Co., while the installation work was carried out by the Post Office engineering staff. About a mile of lead and copper wire was used. All this work was voluntary, and occupied 560 hours of the workers' spare time. There are 59 head-phones at present in use, but the installation consists of 90 points all over the institution—so that 90 phones could be used. A 40ft. mast was presented by Messrs. Brown & Son.

The opening ceremony took place on the 13th October, Major N. A. C. de H. Tufnell, D.L., J.P. (chairman of the Hospital Committee), presiding, supported by the Mayor (who handed over the set to the Hospital), Mr. W. Hawkins, and Mr. H. S. Tuke (hon. treasurer).

SOUTH MIDLAND CENTRE.

It was known that there was an encouraging increase of interest in the work of the Institution in this centre and the record attendance of 72 at the opening meeting of the 1925-26 session confirmed the optimism of the Local Officers. At this first meeting, held on the 28th October, the Chairman had the pleasure of welcoming 25 new members who had been enrolled since the end of the preceding session. The Chairman made the formal presentation to Mr. F. J. Gibbs of the certificate granted by the Council of the Institution to record his securing the first place in the 1924 Essay Competition for Workmen. In congratulating Mr. Gibbs, the Chairman referred to the record of the South Midland District staff in the first two competitions and expressed the hope that the enviable positions obtained by the men in the District would be repeated during the current year. The cheque also awarded by the Council had been posted to Mr. Gibbs in the spring.

Mr. F. J. Gibbs then read a paper entitled, "Telephone Repeaters in practice," which was based on his essay for which the certificate presented earlier in the meeting and the cheque had been given.

Mr. Gibbs at the outset was bold enough to prophesy the imminence of the day when the last trunk pole line was uprooted and the thermionic valves glowed triumphantly in circuits hidden from the eye of the æsthetic wayfarer.

The developments which led to the introduction of repeater stations were described, the desiderata affecting the choice of site and design of the stations explained and the saving in the cost of external conductors quoted.

The apparatus used in a repeated circuit from the point of emergence from the duct was detailed and the importance of the special precautions in the station necessary to secure efficiency stressed.

The paths of the currents in a 2-wire, 2-valve, 1 stage repeated circuit were traced and some details of apparatus testing given. Interesting notes were read about the system adopted for the production of power at stations where energy from an electricity supply undertaking is not available and the capacity of the secondary cell installations was mentioned.

The closing sentences of Mr. Gibbs' paper pictured a halcyon day when the occasions of trunk calls made by subscribers normally of irascible temperament would, under the sweetening influence of the repeaters, be three minutes' oases of amiability in lifetimes' deserts of acerbity.

Encouraging tributes of appreciation of Mr. Gibbs' first paper were made by Mr. J. S. Brown, Capt. Horton, Messrs. Gravill and Traviss, and replies were given to the questions asked by these members.

The Chairman added his mead of praise and expressed the hope that further papers would be read by Mr. Gibbs in future sessions. The audience enthusiastically endorsed these sentiments.

At the second meeting of the session, which took place on the 25th November, the announcement of the gift by Major Comport to the S. Mid. Centre Library of a book, "Building Specifications in Detail," by F. W. Macey, was received with applause.

Mr. J. S. Brown delivered a lecture entitled, "Portsmouth and its Satellite Exchanges."

He described the unique situation, on an island, of the centre of the system, gave some details of the history of the Portsmouth Automatic Exchange, which was opened in 1916, and of the Ex. N.T. and Ex-Corporation Exchanges it superseded, and passed on to a description of the present system at the centre exchange.

The lecturer explained the uses of repeaters and selector repeaters in automatic exchanges and continued by giving details of the equipment at Hayling Island—one of the satellite exchanges—and the method of passing various classes of calls by and to subscribers in that town.

After stating that the Cosham Satellite Exchange will be almost identical with that at Hayling Island, a description of the apparatus at Gosport was given.

The passing of nine classes of calls within the boundaries of the constellation was described with the aid of a series of conventional diagrams. These helpful drawings were remarkably clear although every detail not absolutely essential to the exposition had been eliminated.

The Chairman opened the discussion by thanking Mr. Brown for the great trouble he was taking during the last session in which he would be on the active list of the Department, Mr. Halton followed with congratulations and a string of questions, Mr. Atkins pleaded for a paper on the *principles* of automatic working and Mr. Lockwood asked about the results of a fault in the submarine cables. Mr. Robb concluded the discussion by a tribute to Mr. Brown and his staff for the splendid work done in the substitution of automatic working at Portsmouth for the obsolete systems inherited from the late N.T. Co., and the Corporation.

The Chairman closed the meeting by stating, amidst applause, that the audience had shown by demonstration of their interest that a vote of thanks to Mr. Brown would be superfluous.

Capt. H. Hill, of the Engineer-in-Chief's Office, was the lecturer on the 9th December, his subject being "The Engineering Aspect of Telephone Exchange Accommodation." The first part of the lecture was concerned with principles and procedure and consideration was given in the latter section to standards.

The question of the period for which the site for a proposed Exchange would suffice was first dealt with and the preparation of the schedule of accommodation and the "area of search" maps explained. Capt. Hill gave some details of the considerations which affected the decision when alternative sites were available.

At the consultation stage, between the Engineer-in-Chief and the Architect, only main issues are considered, leaving details to be settled by the Engineer-in-Chief and Superintending Engineer at the plan stage, after which the final sketch plans and heating plans are prepared.

Accommodation details relating to certain fittings were outlined and a description of small standard buildings given.

In part II. leading-in schemes appropriate to Exchanges of different capacities and housed in various types of buildings were discussed and data about the strength, area and surfaces of floors were quoted. The importance of dust exclusion and the resulting ventilation problems was stressed and the heating system favoured described.

The 23 slides passed through the lantern aided the audience in appreciating the points of the discourse.

Opening the discussion, Major Comport thanked the lecturer and heartily supported the policy of holding conferences to settle differences of opinion. Mr. Atkins asked two or three questions and pointed out the urgency of accommodation cases. Mr. Lewis stated that Contractors do not always measure from the inside of the brickwork, Mr. Traviss enquired about a portable battery hut and the Chairman emphasized the importance of distinctive nomenclature.

Capt. Hill replied to the questions and the Chairman's expression of thanks was endorsed with applause.

A.W.L.

NORTH WALES CENTRE.

The first meeting of the present Session was held on the 6th October, 1925, when Mr. R. P. Collins read a paper on "The Development of the Baudot System."

He explained the principles of the system, dealt with the methods of drive and correction—mechanical and electrical—and described the various types of apparatus used. Forty slides were utilised for the purposes of illustration, in addition to the items of apparatus brought for inspection.

Mr. Collins expressed the view that type printing telegraph will in the near future replace Morse circuits—except perhaps the Wheatstone for news distribution, race meetings and special events—and that for this class of work the Baudot may be less suitable because less portable, and because of the longer time required to instal it.

He also referred to the efforts which have been made in America to increase the amount of traffic carried on a single line by the application of wired wireless, a system of connecting a number of Baudot circuits to one line, giving each a different wave length, and providing the necessary filter and receiving apparatus.

At the second meeting on the 3rd of November, Mr. J. H. Whitehead dealt with the question of the Department's costing system and its relation to the distribution of staff under the title of

"Staff proposals based on Unit Maintenance Cost Statistics." The subject was approached by an analysis of the Sectional U.M.C. and plant statistics, which indicated that there were apparently adequate reasons for costs in any Section being regarded as peculiar to that Section and not claimable by other Sections.

It was intimated that the average rates may not be applicable in the case of a single Lineman's load, and that it was now the practice to consider the plant and staff in each Inspector's area as a unit; also that the allowance of full average rates in every instance would probably result in the average rates being increased.

The U.M.C. was not an index of the quality of maintenance, that consideration was met by the Faults Records, etc. The U.M.C. showed what was involved in doing whatever was necessary. Where a steady figure was obtained over separate periods of six months the figure should be recognised and accepted.

From a comparison of Expenditure for 1922-3 and 1924-5 it was shown that the total manhours on certain sub-divisions had appreciably increased even if it were thought that the number of staff authorised had not increased. An explanation of this may be that less internal construction work is being done by the maintenance staff than heretofore.

The results of errors due to units as stated in the Returns differing from those in existence were pointed out. It was also emphasised that the important requirement was to obtain credit for all units claimable, and to ensure this there should be no delay in the closing of Works Orders, etc.

Birmingham was the venue of the third meeting held on the 3rd of December, 1925, when by the courtesy of the Stores Department a room at the Fordrough Lane Depot was used and an inspection of the Factory made. Captain N. F. Cave-Browne-Cave, B.Sc., M.I.E.E., who was to deliver the lecture had also arranged that members should see the Engineering Testing Branch.

Mr. T. Plummer, M.I.E.E., Chairman of the Centre, presided, and Captain Cave read a paper on "The work of the P.O. Engineering Testing Branch at Birmingham."

The lecturer introduced his subject by giving particulars of the branches of the Stores Department and the Engineering Department located at Birmingham, their functions, and the work done.

Some interesting comparisons of the staff and grades employed in these branches were given, together with the yearly value of the stores handled.

It was explained that the Engineer-in-Chief decides the specification and drawing for stores, approves the pattern and the sample with tender, and the general technical principles to be followed in seeking supplies. The Testing Branch carries out the specified tests, approves all such stores before they go to stock, and attempts to arbitrate impartially in any disputes on technical matters between buyer and seller. The Controller of the Stores Department arranges contracts, controls supplies, carries out visual examinations of deliveries, repairs vast quantities of stores, maintains depot stocks, and distributes supplies.

Under the heading of Testing Branch Organisation, reference was made to the functions of the Test Section of the Engineer-in-Chief's Office and the Studd Street Testing Branch. Test report routine, factory test reports, examinations at contractors' works, re-issues examinations, patterns and gauges, volume of rejections, and the accounting arrangements were also outlined.

Finally, the Testing Branch equipment was described with details of the most important tests.

Advantage was taken of the occasion to present a certificate to Mr. S. H. Johnson, who was successful last Session in gaining one of the prizes in the essay competition for workmen arranged by the Intitution.

A.J.W.D.

BOOK REVIEWS.

"Electrical Engineering." By L. A. Hazeltine, M.E. (New York; The Macmillan Co). Pp. 623; 364 figures. Price 30*s*.

In this work the author has attempted to present in a single volume the essential elements of electrical science and its application to electrical engineering. To attain such a result without superficiality, a concise treatment has been necessary so that the book is less suited for self-study than as a college text book where it will be supplemented by the elaborations of a teacher. On the other hand, by very reason of this conciseness, the volume is admirably suited as a book of reference for the electrical engineer.

The first chapter is devoted to the basic ideas of physics which underlie the electrical branches. The author favours the conception of energy as a fundamental dimension (in common with length and time) and mass as a derivative of these quantities, in preference to the conception of mass as a fundamental dimension and energy a derivative. Modern ideas are thus introduced at a very early stage.

The next three chapters deal with the fundamental branches of electrical physics—electrical conduction, electrostatics and electromagnetism. The earlier method of basing electrical theory on the hypothetical distributions and reactions of point charges and point magnetic poles has been abandoned, the author following the methods employed by Steinmetz and others whereby the basic experimental facts are first of all described and these facts then expressed in concise laws which are applied to specific cases.

In Chapters V. and VI. alternating and transient currents and electrical waves are introduced by the employment of complex quantities and vectors.

The succeeding chapter is devoted to conduction in gases and electrolytes. In this chapter various types of rectifiers are described, and the employment of thermionic valves for this purpose and as oscillators is briefly outlined.

Chapters VIII. and IX. deal with electrical measuring instruments and electrical measurements respectively, while the five succeeding chapters are devoted to heavy electrical engineering under the heading of Direct Current Machines, Synchronous Machines, Induction Machines, Transformers and Transmission and Distribution.

A short final chapter of 42 pages outlines the principles of electrical communication. This section of electrical engineering has been summarized rather than described. The telegraph practice referred to is, of course, American.

As the author is so well known as an authority on Radio Telegraphy (his name will be familiar to many readers as the inventor of the Neutrodyne circuit) it is surprising and disappointing to discover that only seven pages have been allocated to Radio Communication. It is a matter for regret that the author has found so little to say on this branch of electrical engineering, which has undergone such rapid development both in research and construction during the last few years.

There are other omissions in the volume as, for example, the subjects of A.C. Commutator Motors, Switchgear and Control Gear. The latter subjects are particularly important and no work on electrical engineering can be considered complete without some reference to them. It is generally more important for an electrical engineer to be able to design a switchboard than to be able to design a machine, as in the one case he has to specify the particular design in full detail while in the other he usually accepts a standard design of the manufacturer. The engineering student (judging from many text books on electrical engineering) appears to be expected to arrive at his knowledge of this intricate and complicated subject by some process of intuition. The present work appears to be free from errors and the author is to be congratulated on the excellent way in which the subject matter is presented. The book is clearly printed and the diagrams are well reproduced, while a comprehensive index is provided.

One of the most satisfactory features of the book for teaching purposes is the inclusion in the text of a large number of numerical examples, many of which are fully worked out, while in the case of the remainder the answers are given.

The method of treatment conforms throughout with modern practice and the book will constitute a useful work of reference to the teacher, student and engineer.

A. J. GILL.

The first three volumes of Messrs. Ernest Benn's "Electrical Engineers' Data Books" are published. This ambitious undertaking has been planned by Mr. E. B. Wedmore, known throughout the Electrical industry as the Director of the British Electrical and Allied Trades Research Association, and a start has been made with three volumes dealing respectively with "Lighting, Traction and Power Distribution," "Manufacture, Design and Laboratory Work," and "Radio Engineering."

The Radio Engineering volume is being published by Messrs. Ernest Benn in conjunction with the Radio Press, Limited.

The object of the series, as seen by Mr. Wedmore, is to fill the gap between the scientist or research worker and the practical engineer for whom the different volumes are primarily intended. The expert work of compilation has occupied more than eighteen months, and every effort has been made to ensure that each volume is absolutely up-to-date.

A special feature is the cheapness of the series, the volumes being published at the uniform price of 15/- each.

"Nogle Statistiske Meddelelser vedrorende Telefonselskaber i Danmark." Statistics of Danish Telephone Companies: 1924-1925.

The report is published by a Government Committee which supervises the concessions to private telephone companies.

During 1924 the telephone receipts, excluding Government telephones in Sonderjylland, amounted to approximately £1,900,000. £670,000 was used in new construction. The capital value of telephone plant and property, allowing for no depreciation, is 197 million kronor. There are 1,700 exchanges, of which 106 are in towns. Mileage of single wire is 1,100,000 km: number of poles, 800,000 (approx. 25 kronor = £1 in 1924).

Some comparative figures of the three largest Companies are as follows:—

	Copenhagen Telephone Company.	*Jydsk Telephone Company.*	*Fyns Communal Telephone Company.*
Population of district	1,324,800	1,362,400	339,400
Subscribers	134,900	78,520	21,460
Town exchanges	41	37	13
Country ,, ...	311	1,139	85
New subscribers: 1924	10,773	5,469	1,790
Ceased subscribers	3,682	2,518	328
Dividend on shares	8%	8%	—
,, ,, loans	5.2%	7.6%	5%

Calls: total: millions		264		110		34·4
,, per sub. local		1,840		1,068		1,251
,, ,, ,, trunk		171		362		408
Staff: Administrative		601		225		55
Operators		2,490		1,925		334
Linemen, etc.		1,024		390		177
Costs: (£1 = 20 to 25 kronor).	Kronor *per sub.*					
Income		195		169		159
Expenses: Wages, salaries ...	70		68		56	
Maintenance ...	20		26		37	
Depreciation ...	30		29		25	
Miscellaneous ...	31		27		33	
Total		151		150		151
Average rental: per sub. ...		135		105		133
Income from calls, per sub. ...		26		58		18
Other receipts, per sub.		34		6		8
			Kronor.			
Income per call		0.10		0.12		0.10
Oper. cost per call		0.023		0.037		0.029
Mtce. per km. aerial wire ...		9.07		5·74		3·33
,, ,, undergd. wire ...		0.48		0.33		0.34

Yearly Rentals, etc.	*Kronor.*
Copenhagen: to main Exchange: installation Fee	300
,, to other Exchange in country: installation fee	200
,, 2 party line: anywhere: installation fee	160
To main Exchange: including 8,000 calls	380
,, ,, ,, ,, 5,500 ,, ...	290
To local ,, ,, 1,200 ,, ...	146
,, ,, ,, 2 party line 2,000 ,, ...	126
In the country: Exchange over 100 subs.	90
,, ,, ,, ,, under 100 ,, ...	85
Fees for 3 minutes' conversation:	
From Copenhagen to surrounding zones	0.20
To Copenhagen from ,, ,, ...	0.12
Inside a country zone	0.06
Between zones 1 and 2	0·30
,, ,, 1 and 3, or 2 and 3	0.40

THE SCIENCE LIBRARY.

Science Museum, South Kensington,
London, S.W.7.

The Science Library is the National Reference Library especially devoted to Pure and Applied Science, and forms part of the Science Museum. The Library is open free to the Public, practically without restriction, daily from 10 a.m. to 6 p.m., or until 8 p.m. on Thursdays and Saturdays. Admission is by ticket, to be obtained by application addressed to "The Director, The Science Museum, South Kensington, S.W.7." A single admission may be granted by the Librarian. The Library contains a very large collection of works on Science, both English and foreign, from the earliest times, including an exceptionally fine set of Periodical Literature, such as the Transactions of Societies, and the Bulletins, Monographs, Reports and other publications of Government Departments, Experiment Stations, Observatories, Research Laboratories, Universities and Scientific Institutions of all kinds, as well as independent Journals. The total number of volumes, bound or for binding, in the Library is 158,000; the number of current Periodicals, 75 per cent. of which are presented, is over 4,700.

The new books received are exhibited for inspection on counters in the Reading-Room for about six months. Similarly, the current parts of some of the more important Periodicals are shown in 500 pigeon-holes along the East side of the Reading-Room. The Author and Subject Catalogues are on cards: the latter, classified minutely on the Decimal System, together with the published bibliographies, provides an Index to the resources of the Library. Special efforts are being made to gather together as complete as possible a collection of the Scientific Literature of the World, so as to make the Library a Central Institution for study and research available to any *bona fide* student.

"Photo-Electricity." By Prof. H. Stanley Allen, M.A., D.Sc., F.Inst.P., F.R.S.E. Published by Longmans, Green & C., 1925. 18*s*. net.

This book is one of a series, entitled "Monographs on Physics," edited by Sir J. J. Thomson and Dr. Frank Horton. The first edition was issued in 1913 and the present volume is a second edition. The aim of the author has been to give a connected view of the subject of the liberation of electrons by ordinary and ultra-violet light, showing how the experimental facts have led up to, and may be expressed in terms of, modern theories of radiation and matter. The introductory chapter gives an outline of the whole subject and is followed by sixteen chapters dealing with photo-electric phenomena, their measurement and practical applications.

The book is well printed and suitably illustrated and a useful bibliography of scientific papers relating to photo-electricity, published in the years 1913-1924, has been incorporated.

A.B.M.

The following prints, published by the International Advisory Committee for Long Distance Telephonic Communications, are on sale at the Offices of the General Secretary to the Committee, 22, Avenue de Messine, Paris, 8C:—

(1) *Report of the work done by the Preliminary Technical Committee for Long Distance Telephony in Europe. (March, 1923).*

Pamphlet in 8 Vo. of 50 pages, 2 illustrations. Price 5 frs. (Add 20% for postage).

This pamphlet contains the exact text of the various proposals made by the Preliminary Technical Committee and also the minutes of the plenary sittings.

(2) *Report of the work done by the first plenary sitting of the International Advisory Committee for Long Distance Telephonic Communications. (Paris 28th April—3rd May,* 1924).

Pamphlet in 8 Vo. of 68 pages. Price 5 frs. (Add 20% for postage).

The International Advisory Committee for Long Distance Telephonic Communications composed by the official representatives of the Telephone Administrations of Germany, Austria, Belgium, Denmark, Spain, Finland, Great Britain, Hungary, Italy, Lettland, Luxemburg, Norway, Holland, Poland, Serbia Croatia and Slavia, Sweden, Switzerland, Czecho-Slavia, France, after considering as the basis for discussion the proposals made by the Preliminary Technical Committee has arranged effectively the organisation of the International Telephony in Europe by adopting unanimously the recommendations contained in this pamphlet.

(3) *Report of the work done by the second plenary meeting of the International Advisory Committee for Long Distance Telephone Communications. (Paris, 22nd—29th June,* 1925).

Pamphlet in 8 Vo. of 200 pages under print.

Standard specifications for the supply of international cables and their accessories are appended to the proposals relating to the specification for cables, instruments and methods of measurements for maintaining the international circuits.

The disposition relating to the measures required for the protection of the telephonic lines against interference by power systems at high current or potential, have been set out after a discussion between the official delegates of the Telephones Administrations of Europe, the official delegates of the International Union of Railway lines, and the official delegates of the International Conference for the great systems of electric power at high tension.

These documents are of the utmost importance to those interested in the modern technique of telephonic communications.

(4) *Nomenclature of the International Telephonic Circuits existing in Europe on the 1st January,* 1925.

Pamphlet in 8 Vo. of 80 pages, of which 73 pages are tables. Price 12 frs. (Add 20% for postage).

(5) *Statistics of the International European Telephonic Traffic.* (1924-1925).

Pamphlet in 8 Vo. of 44 pages, of which 19 pages are tables. Price 7 frs. (Add 20% for postage).

The data contained therein has been assembled by the various Telephone Administrations during the second half of the year 1924 and the first half of the year 1925.

(6) *Schematic map of the International Telephonic Cables in Europe.*

The map to scale 4,000,000°, in two colours on strong paper, is sold for 10 frs. (Add 20% for postage).

It shows the approximate route for all the existing or proposed telephone cables, the number of pair/conductors and spacing of the various telephone repeater stations.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Aitken, R.	Asst. Staff Engineer, E.-in-C. Office.	Superintending Engr., Scot. West District.	1-12-25
Comport, Major G. H., M.C.	Asst. Suptg. Engr., S. Mid. District.	Asst. Superintending Engineer, In charge of Ireland N. District.	To be fixed later.
Kitchen, H.	Executive Engineer, N. District.	Asst. Staff Engineer, E.-in-C. Office.	1-12-25
Richardson, J. ...	Executive Engineer, Scot. W. District.	Asst. Superintending Engineer, S. East District.	1-11-25
Mercer, C. J.	Executive Engineer, E.-in-C. Office.	Asst. Staff Engineer, E.-in-C. Office.	22-10-25
Hines, Capt. J. G. ...	Executive Engineer, London District.	Asst. Superintending Engineer, London District.	24-10-25
Anson, B. O.	Executive Engineer, E.-in-C. Office.	Asst. Staff Engineer, E.-in-C. Office.	23-10-25
Roach, C. G.	Executive Engineer, S. West District.	Asst. Superintending Engineer, S. Mid. District.	To be fixed later.
Bellwood, G. F. ...	Assistant Engineer, N. District.	Executive Engineer, N. District.	1-12-25
Leigh, C.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	13-11-25
Turner, J. W. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	27-10-25
Johnson, A. S. A. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	10-11-25
Faulkner, H.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, In charge Rugby Wireless Station.	7-11-25
Mathew, K. R. ...	Skilled Workman, Class I.	Inspector, Scot. East. District.	5-1-25
Lambert, J. G. ...	,,	,,	5-1-25
Reid, W. A.	,,	,,	4-4-25
Middlemiss, W. A. ...	,,	,,	5-1-25
Douglas, J. H. ...	,,	,,	5-1-25
Robertson, J.	,,	,,	27-4-25
Abbotts, G. E. ...	S.C. & T.	Repeater Officer, Cl. II., Eastern Dist.	10-6-25
Stone, T. H.	Skilled Workman, Class I.	Inspector, London District.	10-5-25
Griffiths, C. E. ...	,,	,,	26-7-25
Boys, W. E.	,,	,,	9-9-25
Pullan, J. G. W. ...	,,	Inspector, Testing Branch.	22-6-25
Repton, G.	,,	Inspector, N. East District.	17-6-25
Akester, G. B. ...	,,	,,	3-6-25
Terry, H. E.	,,	,,	10-9-25
Harper, J. P.	,,	,,	4-10-25
Lally, J.	,,	,,	4-8-25
Garrard, A. W. O. ...	,,	Inspector, N. Mid. District.	13-10-25
Strong, H. A.	,,	,,	7-5-25
Hemington, H. ...	,,	,,	22-7-25
Brown, A. H.	,,	,,	17-5-25
Taylor, C. H.	,,	Inspector, S. Mid. District.	23-2-25
Green, F. R.	,,	,,	5-1-25

STAFF CHANGES.

APPOINTMENTS.

Name.	Grade.	Appointed.	Date.
Somerville, H. B. ...	Probationary Assistant Engineer. E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-11-25
Jolley, E. H.	,,	,,	,,
Pidgeon, J. E. ...	,,	,,	,,
Taylor, T. A.	,,	,,	,,
Jackson, J. M. ...	,,	,,	,,
Williams, L. E. ...	,,	,,	,,
Wallcroft, F. E. ...	,,	,,	,,
Farnes, G. H.	,,	,,	,,
Hines, R. J.	,,	,,	,,
Dixon, E. J. C. ...	,,	,,	,,
Gray, W. D.	,,	,,	,,
Gray, G.	Chief Inspector, N. Wales District.	Assistant Engineer, Egyptian Government (Seconded).	5-11-25
Jarvis, J, W.	Inspector, Scot. East. District.	Egyptian Tele. Department.	13-11-25
Cross, W. H.	Probationary Inspector.	South Lancs.	7-6-25
Balcombe, F. G. ...	,,		7-6-25
Britton, G. A. C. R....	,,	Testing Branch.	8-6-25
Gilby, F. W.	,,	,,	8-6-25
Helman, S. L.... ...	,,	,,	14-6-25
Summers, F.	,,	,,	23-6-25
Hawkins, N. A. ...	,,	,,	29-6-25
Sanders, A. E. ...	,,	,,	30-6-25
Anderson, E. W. ...	,,	,,	1-7-25
Couch, P. R.	,,	,,	21-7-25
Robinson, A. K. ...	,,	,,	15-9-25

TRANSFERS.

Name	Grade.	Transferred.		Date.
		From.	To.	
Smart, E. V. ...	Exec. Engineer.	E.-in-C. Office.	London Dist.	13-11-25
Horn, C. O. ...	Asst. Engineer	E.-in-C. Office.	Rugby Wireless Station.	7-11-25
Davies, T. A. ...	Pro. Asst. Engr.	Testing Branch.	E.-in-C. Office.	
Bewick, W. ...	,,	,,	,,	1-9-25
Barker, P. L. ...	,,	,,	,,	
Towers, R. ...	Chief Inspector.	E.-in-C. Office.	Grimsby-Skegness Wireless Station.	4-10-25
Roberts, F. R. ...	Second Officer.	H.M.T.S. "Alert."	H.M.T.S. "Monarch."	1-11-25
Dunk, W. G. ...	Inspector.	Testing Branch.	E.-in-C. Office.	21-6-25
Sturgess, H. E. ...	,,	E.-in-C. Office.	Rugby Wireless Station.	31-9-25

RETIREMENTS.

Name	Grade.	District.	Date.
Crompton, Capt. C. O.B.E.	Superintending Engineer.	Scotland West.	30-11-25
Evans, Lt.-Col. Wm.. O.B.E., M.C. ..	Asst. Superintending Engineer.	N. Ireland.	9-11-25
Callender, R. W. ...	Executive Engineer.	London.	31-12-25
W. G. Webb	Inspector.	,,	13-8-25
J. H. Walker	,,	,,	16-11-25
F. Limb	,,	E.-in-C. Office.	28-11-25

STAFF CHANGES.

DEATHS.

Name.	Grade.	District.	Date.
A. A. Kent	Inspector,	S. Mid. District.	7-8-25

CLERICAL ESTABLISHMENT.

PROMOTION.

Name.	Grade.	Promoted to	Date.
Barrett, C. H. ...	Clerical Officer, E.-in-C. Office.	Executive Officer, E.-in-C. Office.	28-10-25
Elsworth, C.	Clerical Officer, S.E. District.	Higher Clerical Officer, S. Lancs. District.	1-10-25
Norman, R. D. S. ...	Clerical Officer, N. District.	Higher Clerical Officer, N. District.	1-10-25
Hansford, W.	Clerical Officer, S. Wales District.	Higher Clerical Officer, N. Wales District.	20-9-25

APPOINTMENTS AS CLERICAL OFFICER.

Name.	District.	Date.
Stepney, H.	S. Lancs.	23-8-25
Roper, T. W.	S. East.	23-8-25
Hill, T. J.	S. West.	23-8-25
Martin, E.	London.	6-9-25
Nash, J. A.	E.-in-C. Office.	17-9-25
Fyfe, A. Y.	N.	20-9-25
Fear, G. H. L.	N. West.	11-10-25
Gray, M.	London.	25-10-25
Laird, W. W.	do.	1-11-25
Mickleburgh, G. B. ...	E.	8-11-25

TRANSFERS.

Name.	Rank.	Transferred.		Date.
		From.	To.	
Warren, P. J. ...	Clerical Officer.	Land Regy. N. Ireland.	S. Lancs. Dist.	1-9-25
Hughes, P. ...	,,	Stores Dept.	S.W. Dist.	20-9-25
Postlethwaite, R. R.	,,	N.W. Dist.	S.E. Dist.	11-10-25
Thorpe, F. E. ...	,,	A.G.D.	Ireland, N. Dist.	18-10-25
Moses, H. W. ...	,,	S. Lancs. Dist.	N. Dist.	1-11-25
Thorne, C. ...	,,	E. Dist.	Sec.'s Office.	8-11-25
Durham, E. C. ...	,,	Secy.'s Regy.	L'd'n Eng. Dist.	8-11-25
Spink, S. T. ...	,,	S.M. Dist.	S. East. Dist.	15-11-25
Martin, E. ...	,,	L'd'n Eng. Dist.	Scot. E. Dist.	15-11-25
Whelton, M. ...	,,	London Eng. Dist.	London Postal Service.	15-11-25
Other Changes.				
Kennedy, W. E. H.	Exec. Officer.	E.-in-C. Office.	Appointed Asst. Inspector Min. of Health.	28-9-25
McCandless, L. I.	Clerical Officer.	Ireland, N.	,,	5-10-25
McGann, R. H. ...	,,	N. Dist.	Appointed Asst. Supt of Traffic.	18-10-25
Evans, J.	,,	London Dist.	,,	18-10-25
Dean, H. G. ...	,,	London Dist.	,,	1-11-25
Topham, F. ...	,,	N.E. Dist.	,,	18-11-25
Hamilton, J. Mc. L.	,,	N. Wales Dist.	,,	22-11-25

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4. Applications for the Award, accompanied by full details of the improvement, should be addressed to the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), London, E.C.1.

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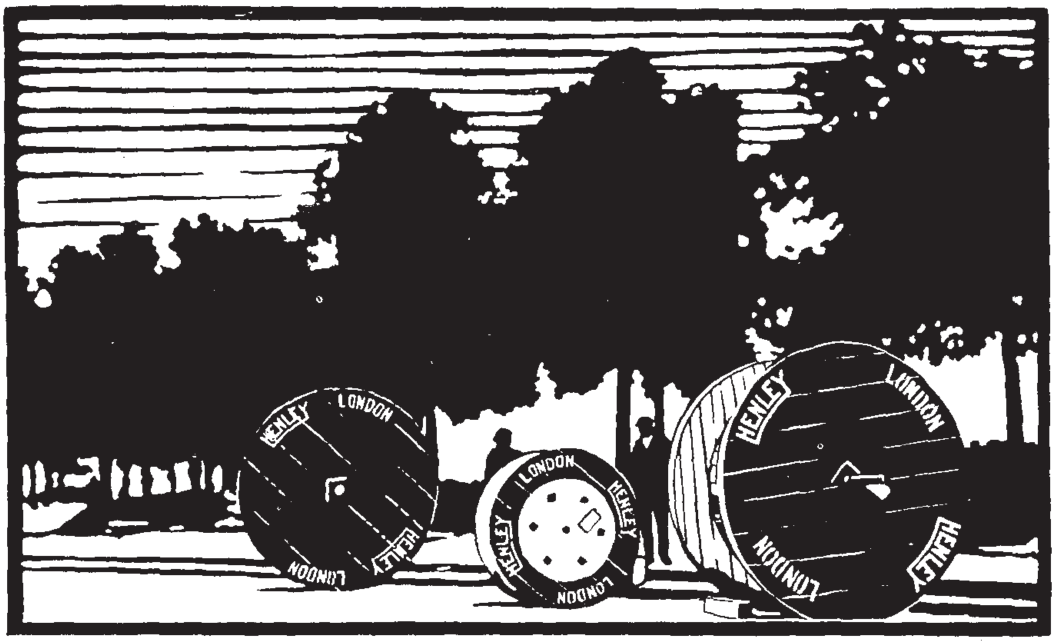
Secretary.



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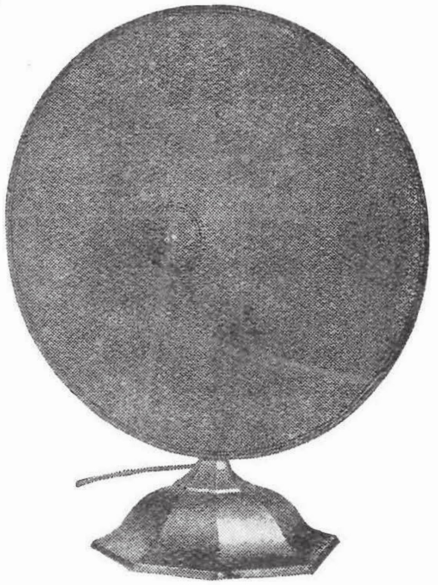

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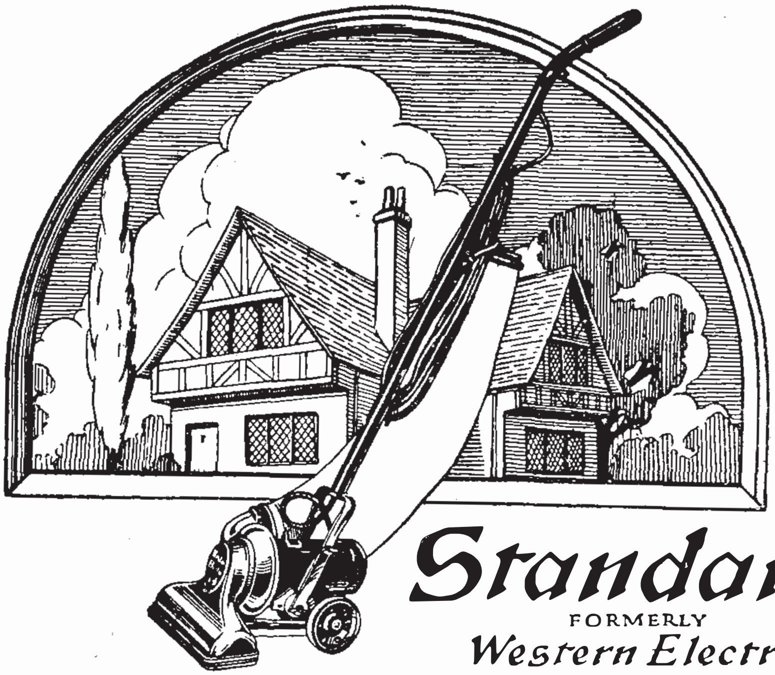

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PAGE
Annales des Postes, Telegraphes et Telephones ... xvi
Automatic Telephone Mfg. Co., Ltd. iii
British L.M. Ericsson Mfg. Co., Ltd. v
Creed & Co., Ltd. ... ... viii and ix
Henley's, W. T., Telegraph Works Co., Ltd. ... xi
I.P.O.E.E. Papers xvii
Johnson & Phillips, Ltd. xx
London Electric Wire Co. & Smiths, Ltd. ii
N.V. Electriciteits Maatschappy "Zeva" xvi
Peel-Conner Telephone Works, Ltd. xix
Pitman & Sons, Ltd. ii
Relay Automatic Telephone Co., Ltd. x
Rentell S., & Co., Ltd. xv
Siemens Bros. & Co., Ltd. ... ... vi and vii
Smith, Frederick, & Co. xv
Standard Telephones and Cables, Ltd. ... xii and xiii
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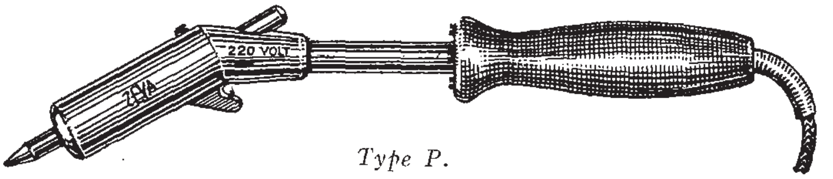

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Errors in Part 3, Vol. XVIII., October, 1925, issue.

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Corrections to article on
"Junctions working between Automatic and Manual Exchanges."

Page	231	GB should read GG.
Fig.	13	Relays (from left to right) should be labelled C, D and S.
,,	14	Relays (from left to right) should be labelled S, H, CO and A.
Page	238	Sixth line from bottom—LA should read LB.
,,	239	Number and title of Fig. 17 should be placed under second diagram on page 240.
,,	240	Number and title of Fig. 19 should be placed under diagram on page 239.
,,	241	First diagram should be labelled Fig. 22—"Magneto and C.B.S. No. 1 Exs. Dial Key per Junction."
,,	241	Second diagram should be labelled Fig. 23—"C.B.S. No. 1 Exs. Outgoing; Loop or battery dialling or outgoing portion of bothway, battery dialling."
,,	242	First diagram should be labelled Fig. 20—"Non Mult. Magneto Exs., Outgoing loop or battery dialling or outgoing portion of bothway, battery dialling."
,,	242	Second diagram should be labelled Fig. 21—"Non Mult. Magneto Exs., outgoing portion of Bothway—Loop dialling."
,,	242-3	Delete references to C.B.S. No. 3 Exchanges.
,,	243	Fig. 25. Relay marked E should be D; Relay A should be L; Relay C should be CO.
,,	244	Fig. 26. Relay D should be S$_1$ Top Jack and lamp should be No. 2. Bottom ,, ,, ,, ,, ,, No. 1.
,,	245	Fig. 27. Relay C.L. should be F. ,, D.D. ,, ,, M. ,, D ,, ,, S.
,,	246	Fig. 29. Relay D ,, ,, S. ,, D.D. ,, ,, M.
,,	246	Last line, springs 11 and 9 should read 10 and 9.
,,	,,	Third last line, comma after D.M.